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ABSTRACT

This publication was produced by the ERIC Information Analysis Center for Science, Mathematics, and Environmental Education in cooperation with the National Association for Research in Science Teaching (NARST) to provide abstracts of most of the papers presented at the NARST annual conference in Chicago, Illinois, on April 15-18, 1974. The abstracted papers cover a wide range of topics of importance in science teaching and many report the results of current research in science education. (JR)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING

47TH ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

Sheraton Blackstone Hotel
Chicago, Illinois
April 15-18, 1974

ERIC Information Analysis Center for
Science, Mathematics, and Environmental Education
400 Lincoln Tower
The Ohio State University
Columbus, Ohio 43210

PREFACE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Chicago, Illinois, April 15-18, 1974.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Robert E. Yager who organized the program and obtained most of the abstracts, to Dr. Patricia Blosser for extensive assistance in preparing the abstracts, and to Mrs. Maxine Weingarth, Miss Linda Hemmler, and Mrs. Charlotte Helgeson for typing and compiling.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC System.

March, 1974

Stanley L. Helgeson
Editor

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GENERAL SESSION I

Presiding: Wayne W. Welch, President, University of Minnesota,
Minneapolis, Minnesota.

Speaker: Joseph J. Schwab, University of Chicago,
Chicago, Illinois.

"The Coming Duty of Science Teaching"

SPECIAL SYMPOSIA

Symposium A. "Research Concerning Classroom Environments."

Presiding: Robert K. James, Kansas State University, Manhattan, Kansas.

1. "Research on Mathemagenic Behavior: Implications for Science Instruction and Learning." John J. Koran, Jr., University of Florida, Gainesville, Florida.
2. "Symposium on Research Concerning Classroom Environments." Colin N. Power, University of Queensland, St. Lucia, 4067, Australia.
3. "Effects of Elementary and Secondary Classroom Environments on the Training of Preservice Teachers." William R. Brown, Old Dominion University, Norfolk, Virginia.

RESEARCH ON MATHEMAGENIC BEHAVIOR:

IMPLICATIONS FOR SCIENCE INSTRUCTION AND LEARNING

John J. Koran, Jr.
University of Florida
Gainesville, Florida

Mathemagenic behaviors can be thought of as "behaviors that give birth to learning." These behaviors are overt and covert in nature and can be observed in the context of the interaction between teacher and student, student and student or student and curriculum materials. In the latter case the behaviors that give birth to learning might occur in text materials, in a laboratory setting, in response to a single concept film, or in similar situations. The purpose of this paper will be to review research which can be classified in the following three categories and to project promising extensions of this research.

A. Teacher-Student Interaction:

Mathemagenic studies have been conducted using the teacher as the one who verbally establishes the setting for student mathemagenic behavior. This research and extensions of it may be useful in improving classroom and laboratory learning and instruction.

B. Curriculum Materials:

Although science education and scientists have been notorious for developing curriculum materials (written and visual) that are devoid of mathemagenic behavior opportunities, it is possible to design curricula to not only optimize learning, but to increase student overt and covert responsiveness (e.g., mathemagenic behaviors).

C. Acquisition of Knowledge:

Much attention has been given to hierarchal organization of content in science, Science: A Process Approach (AAAS) and Ed Kurtz's materials, among others. Some learning theorists call this the "Calculus of practice" as opposed to fostering learning through student action in response to effectively designed materials. This section attends to that issue.

SYMPOSIUM ON RESEARCH CONERNING

CLASSROOM ENVIRONMENTS

Colin N. Power
University of Queensland
St. Lucia, 4067, Australia

In this paper the models and assumptions underlying classroom interaction research and research using questionnaire data (e.g. Walberg and Anderson studies) relating to classroom environments are critically examined. It is argued that the payoff of research on classroom environments has been low because of measurement deficiencies and/or inadequacies in the research models employed. For more than thirty years social psychologists have been stressing the need to consider all the properties of the person and of his environment in accounting for human behavior. It is, after all, the interactions between a complex individual student and the equally complex learning environment that determines instructional outcomes. It follows, that more multivariate studies of person-environment interactions are needed. In selecting variables for these studies, it is believed that greater account needs to be taken of theoretical views underlying the science curriculum and learning processes used and of the results of research on classroom environments. Hopefully, some generalizations about the general effects of different combinations of teaching strategies and curriculum materials for different types of students and teachers should emerge. The next step in the proposed research chain involves working with teachers on action research projects, finding the combinations of materials and strategies and the adaptations which work for them and their students.

EFFECTS OF ELEMENTARY AND SECONDARY CLASSROOM ENVIRONMENTS ON THE TRAINING OF PRESERVICE TEACHERS

William R. Brown
Old Dominion University
Norfolk, Virginia

Numerous factors affect the classroom environment. These factors in turn interact with and affect the attitude and performance of the preservice teacher who has an opportunity to participate in public school classrooms. Five major effects on preservice teachers are: (1) cultural attitudes and/or knowledge, (2) types of science activities used in urban/suburban settings in and prior to student teaching, (3) the influence of cooperating teachers on student teachers, (4) the preservice teacher's perception of what should happen in a classroom before-during-after student teaching, and (5) the preservice teacher's self-perception.

Fourteen studies conducted between 1967 - 1972 have been identified that involved early experiences of preservice science and mathematics teachers in the public schools. Variables or methods which were used to evaluate programs or components of programs were: (1) grades, (2) ratings by supervisors, (3) interaction analysis, (4) standardized tests, (5) frequencies, (6) attitude scales, (7) multivariate analysis, and (8) correlations. The most frequent research design compared an experimental or pilot program to a conventional program. The comparisons most frequently involved a single group of participants in one cycle of a program. The pretest-posttest method was used frequently.

A series of six investigations was conducted at The Ohio State University between 1968-1972. The results of these studies indicate that preservice teachers are affected by the five variables cited above, when these teachers are prepared in a field-based environment. Preservice teachers should be placed in public school classroom environments where as many as possible of the following conditions exist. (1) The cooperating teacher is rated high by his students on the Science Classroom Activity Checklist: Student's Perceptions. (2) The cooperating teacher has a favorable attitude toward the laboratory facilities that are available for his use. (3) Course content improvement projects are used in the manner for which they were designed. (4) The cooperating teacher has a favorable attitude toward the textbook used by his students. (5) Classroom students indicate that they have favorable attitudes toward the science class in general. (6) The classroom students state that their teacher positively influences their liking of the science class. (7) The cooperating teacher has a full schedule of classes all of which do not require the same basic preparation and teaching strategies.

SPECIAL SYMPOSIA

Symposium B. "Curriculum Research and Development Efforts at the University Level."

Presiding: James E. Maffett, El Paso Community College, Colorado Spring, Colorado.

1. "College Curricula and Programs at Western Washington State College." LeVon Balzer, Western Washington State College, Bellingham, Washington.
2. "Curriculum Research and Development in Higher Education." George T. O'Hearn, University of Wisconsin-Green Bay, Green Bay, Wisconsin.
3. "Curriculum Research and Development in Science at a New Senior University." James J. Gallagher, Governors State University, Park Forest South, Illinois.
4. "The National Science Foundation - Its Stake in Curricular Change." John I. Snyder, National Science Foundation, Washington, D.C.
5. "Science Education at The Evergreen State College." Lawrence Eickstaedt, The Evergreen State College, Olympia, Washington.

COLLEGE CURRICULA AND PROGRAMS IN SCIENCE AT WESTERN WASHINGTON STATE COLLEGE

LeVon Balzer
Western Washington State College
Bellingham, Washington

The major challenges to which Western has been responding are: (1) the need for interdisciplinary studies, (2) the need for flexible programs which respond rapidly to a high rate of change in science and society, and (3) the need for the benefits of a small college atmosphere on a large campus. The main administrative procedure has been the creation of Cluster Colleges. These colleges are communities which develop alternative educational perspectives and mechanisms, including interdisciplinary approaches. The principal rationale for this procedure was that it was too difficult, within the framework of the traditionally competitive departmental structure, to initiate innovative curricula, and that an alternative structure was needed. A second rationale was that the gradual evolution of interdepartmental programs was too slow to respond adequately to current rates of change on various fronts.

The largest college at Western is the College of Arts and Sciences. The first cluster college to be added was Fairhaven College, characterized by its small college atmosphere, experimental instructional approach, semi-distinct campus, selective admissions, humanities orientation, and required residence on the Fairhaven campus. This last requirement has subsequently been modified. A few science courses are offered at Fairhaven, but most work by Fairhaven students in science concentrations is done at other colleges of Western.

Since the opening of Fairhaven in 1968, the College of Ethnic Studies and Huxley College of Environmental Studies have been initiated. Huxley College is of particular interest here because of its interdisciplinary nature and its principal basis in the sciences. It is an undergraduate college with a core program in environmental studies. Some of these courses have a strong science basis, while others have social, political, and cultural orientations. Problem Series, Seminars, Concentrations, Intrasessions, and Work Internship Programs are offered. Students also take supporting science courses in various departments of the College of Arts and Sciences. There is now a cooperative M.S. program between the Geography Department and Huxley College. Another between the Biology Department and Huxley College is under development.

A second procedure in response to the challenges listed has been the development of the General Studies Department in the College of Arts and Sciences. It offers courses which are interdisciplinary in nature and which partially fulfill the General Education requirement. It also offers a Liberal Studies major. The general education requirements in science are met through specified courses in the science departments, however. The number of courses available for this purpose and the student choice among these courses is currently being raised.

Numerous additional interdisciplinary and applied programs in science and education are offered at Western. A few of these are as follows: (1) Interdepartmental Science Education Program and Science Education Center staffed jointly by five departments (Biology, Chemistry, Education, Geology, Physics), (2) Microteaching in local public schools as a regular component of the Science Education Program, (3) Western leadership in state-wide inter-institutional sponsorship of Anacortes Marine Site, (4) "Block" scheduling in Biology, Geology, and Huxley College for undergraduates to work for a full quarter at the Anacortes Marine Site, (5) Field-centered programs for the preparation of teachers in the Education Department and the Science Education Program, (6) Chemistry Learning Center, (7) Biology Core Program, (8) Computer Assisted Instruction, and (9) Several aspects of the Lummi Indian Aquaculture Project.

CURRICULUM RESEARCH AND DEVELOPMENT IN HIGHER EDUCATION

George T. O'Hearn
University of Wisconsin-Green Bay
Green Bay, Wisconsin

The development of interdisciplinary courses in higher education requires a curricularly viable structure to supplement and/or supplant the structure of the disciplines as used in traditional instructional modes. Well defined environmental problems provide one such structure. The use of a problem focus forces the integration of conceptual structures for problem analyses and solutions and the assessment of the human impact of the alternative solutions. The problem focus also permits a reversal of the usual time-orientation of instruction from the past to the future. Students, using the several science disciplines, construct problem solutions and examine the consequences of these solutions in terms of alternative futures.

Success of an interdisciplinary instructional program using a problem-focused structure is assessed in terms of the impact on people--both students and faculty. After five years of development and operation at the University of Wisconsin-Green Bay, the interdisciplinary courses in the sciences continue to prosper. New instructional materials are being evolved. Students are using the techniques developed in these courses in community-based projects and post-graduate employment. Graduates of the program are successfully pursuing graduate studies at numerous other institutions of higher education. Positive impact is noted on faculty as judged in terms of retention rate, publications and general satisfaction with the instructional program.

Impact on the University is also noted. Enrollment patterns continue to strengthen in terms of FTE count, ability level of students and geographic distribution of student origins. Development of interdisciplinary instructional courses and units continues. Increased involvement in community-based programs, including environmental studies and regional planning is reported. Faculty with doctorates in the physical, biological and social sciences have formed interdisciplinary research teams to pursue study of selected environmental problems.

Management of interdisciplinary instruction requires a reordering of University organization. Budget power is placed in the hands of interdisciplinary committees rather than in discipline-centered departments. Faculty merit and promotion are controlled by the interdisciplinary committees and not by the disciplinary-based departments.

Curriculum research and development following interdisciplinary lines requires a total commitment in terms of University organization, faculty and student involvement and commitment of resources. The model reported is based on developments at the University of Wisconsin-Green Bay.

CURRICULUM RESEARCH AND DEVELOPMENT IN SCIENCE AT A NEW SENIOR UNIVERSITY

James J. Gallagher
Governors State University
Park Forest South, Illinois

Several new universities have been established in recent years. Science programs in many of these are being developed using new organizational patterns.

The author will report on development of an upper-division and graduate program in a new senior university. The program is organized on interdisciplinary, problem focused lines and includes concentration at the baccalaureate and masters levels in science, science teaching, and health science. Instruction is performance-based and criterion-referenced. The population of students for whom this program is intended includes the broad spectrum of people found in metropolitan areas, especially from low-middle income and minority families.

Topics to be discussed include:

a. Interdisciplinary content organization.
b. Developing performance-based, criterion-referenced learning modules.
c. Organization and implementation.
d. Formative evaluation.
e. Next steps in development.

THE NATIONAL SCIENCE FOUNDATION -

ITS STAKE IN CURRICULAR CHANCE

John L. Snyder
National Science Foundation
Washington, D.C.

For many years the National Science Foundation has been involved with attempts to improve science teaching at the college level, mostly through the support of specific curriculum and materials-development projects. Although some of these have proven successful, the following problems still exist. Among them are:

1. Excessive duplication of effort.
2. Inadequate dissemination of good materials and procedures.
3. Lack of adequate materials in some new areas.

A reorganization of National Science Foundation's Education Directorate should enable the Foundation to provide financial assistance for work that directly confronts some of these issues.

SCIENCE EDUCATION AT THE EVERGREEN STATE COLLEGE

Lawrence Eickstaedt
The Evergreen State College
Olympia, Washington

From its inception in 1967, The Evergreen State College has been concerned with developing new and alternative modes of instruction and, as a result, the student of science at Evergreen has a variety of curricular offerings from which to choose.

New students are encouraged to participate in Coordinated Studies programs, which are interdisciplinary, full-time courses of study which typically involve three to five faculty and 60 to 100 students studying subject matter and carrying out research related to a central thematic topic. Political Ecology, Space, Time and Form, and Natural and Social Science: A Modular Approach are a few examples of basic programs which have been science-oriented. Matter and Motion and The Ecology and Chemistry of Pollution are two advanced Coordinated Studies programs which offer training in more specific areas of science.

Further, more detailed work in science may also be carried out through group and individual contracted studies. Internships with governmental agencies and research organizations also add a great deal to the variety of options available to the science student.

SPECIAL SYMPOSIA

Symposium C. "Piaget's Contribution--Applications and Mis-Applications to Students, Teachers, and Curriculum."

Presiding: Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

1. "A Piaget Based Developmental Model for Criterion Based Assessment." Ronald J. Raven and Robert Guerin, State University of New York at Buffalo, Buffalo, New York.
2. "Implications of Piaget's Theory of Child Development for Curriculum." Robbie Case, University of California at Berkeley, Berkeley, California.
3. "The Applicability of Piaget to Contemporary Curriculum Reform?" Barry A. Kaufman, University of Hartford, West Hartford, Connecticut.
4. "Changing Teachers' Perception of 'Learning': An Application of Piaget's Theory and Experiments." Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

A PIAGET BASED DEVELOPMENT MODEL FOR CRITERION BASED ASSESSMENT

Ronald Raven

and

Robert Guerin
State University of New York
Buffalo, New York

Piaget's description of the development of concepts indicates that criterion reference measures must include a variable involving a developmental schema. Previous work by Raven on task dimensions suggests that a logical operations component could serve as the developmental variable. The Raven's Test of Logical Operations (RTLO) is currently being used as a model for developing criterion reference measures of science concepts. The studies that have been completed suggest that when the same concepts are organized according to the logical dimensions of the RTLO major differences occur in achievement across the logical operations dimensions. The studies show that criterion referenced assessment of content is a function of the levels of the logical operations being used in the assessment of a given student at a specific developmental stage.

IMPLICATIONS OF PIAGET'S THEORY OF CHILD DEVELOPMENT FOR CURRICULUM

Robbie Case
University of California
Berkeley, California

The present paper explores the educational relevance of three of Piaget's most basic empirical findings: (1) the fact that, before they begin using adult structures, children use structures of their own making which perform the same function (albeit less adequately), (2) the fact that children's structures are less complex than adults', and (3) the fact that possession of an uncomplicated structure can actively interfere with the acquisition of a more sophisticated structure (unless the inadequacy of the simple structure is fully understood). Evidence is presented which suggests that many classroom learning difficulties may be able to be overcome if the psychological significance of each of these empirical findings is appreciated and if, under appropriate conditions, one or more of the following curricular modifications is introduced; (1) the sequence of activities is redesigned so that even the earliest activities serve the same function as the terminal activity, (2) the complexity of each activity is drastically reduced, and (3) care is taken to uncover spontaneously acquired notions or skills which may be interfering with the ones being taught.

THE APPLICABILITY OF PIAGET TO CONTEMPORARY CURRICULUM REFORM?

Barry A. Kaufman
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West Hartford, Connecticut

It is the primary purpose of this paper to present the distinction between the actual contributions of Jean Piaget regarding epistemological questions and the manner in which these contributions have been interpreted to provide a basis for current educational curriculum reform. It is the contention of the author that the Piagetian theory concerning the nature of knowledge and how Man acquired knowledge has little applicability to contemporary American education. However, if educational theorists could truly understand what Piaget is saying, it could cause a revolution in education.

The author critically examines the epistemological position of Piaget in respect to the nature of knowledge and how Man comes to know. As part of this examination, the author investigates the Piagetian methodology utilized to ascertain the development of logical thought process.

CHANGING TEACHERS' PERCEPTION OF 'LEARNING':

AN APPLICATION OF PIAGET'S THEORY AND EXPERIMENTS

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Iowa City, Iowa

There have been a large number of published articles attesting to attempts by educators and psychologists to investigate various aspects of Piaget's theory. These efforts have ranged in quality from ill-advised training studies (in which subjects are trained to parrot task responses) to studies which are carefully based in an appropriate theoretical framework. One commonality among most investigations, however, is their purpose of investigating how Piaget's theory and experiments apply to students and curriculum. Little has been done in utilizing Piaget's theory and experiments in pre-service and in-service teacher programs.

This presentation will suggest and discuss various ways in which teacher education programs can employ and benefit from the application of several active components of Piaget's theoretical and experimental formulations.

SPECIAL SYMPOSIA

Symposium D. "Developing and Evaluating Materials for Training Science Teachers."

Presiding: James R. Okey, Indiana University, Bloomington, Indiana.

1. "Developing Self-Directed Learning Guides for Process Skills." David P. Butts, University of Texas, Austin, Texas.
2. "Developing and Evaluating Materials for Training Teachers to Use Bloom's Mastery Teaching Strategy." Jerome L. Ciesla, Florida State University, Tallahassee, Florida.
3. "Individualizing In-Service Preparation for ISCS Teachers." William R. Snyder, Florida State University, Tallahassee, Florida.

Discussants: Hans O. Andersen, Indiana University, Bloomington, Indiana.

William Capie, University of Georgia, Athens, Georgia.

DEVELOPING SELF-DIRECTED LEARNING GUIDES
FOR PROCESS SKILLS

David P. Butts
University of Texas
Austin, Texas

The isolation of competencies needed by teachers to facilitate their successful experience in teaching science is a significant task. The development of alternative strategies by which teachers can acquire the competencies which they need is an equally formidable task.

Based on several years of research-development efforts, a series of twenty-three science competencies has been identified. Through extensive efforts, both group-based instructional modules and self-directed modules have been developed for teacher education programs. The development process for these modules has involved a series of key steps that fit together into a three-phase cycle.

I. - Initial design

II. - Pilot test and redesign

III. - Field test and final design

The criteria for acceptance at the end of each phase are best expressed as a cumulative collection. For example, acceptance at the end of Phase I has been basically the staff review of the product for its clarity of communication and feasibility in operation. Acceptance at the end of Phase II is based on the staff review plus student performance and feedback. Acceptance at the end of Phase III includes staff review but is more heavily weighted on instructor feedback, student feedback, and performance.

DEVELOPING AND EVALUATING MATERIALS FOR TRAINING TEACHERS TO USE BLOOM'S MASTERY TEACHING STRATEGY

Jerome L. Ciesla
Florida State University
Tallahassee, Florida

The development and evaluation procedures used in the production of a self-instructional module entitled TEACHING FOR MASTERY are discussed. Particular attention is given to the integration of the developmental activities and the day-to-day preparation of science teachers in typical science methods courses. The evolution of the product from its initial idea through its development, several revisions, and evaluations is traced. Practical suggestions for evaluating teacher training materials in the context of science teacher preparation programs are also given.

INDIVIDUALIZING IN-SERVICE PREPARATION FOR ISCS TEACHERS

William R. Snyder
Florida State University
Tallahassee, Florida

Most curriculum projects have seen the need to follow their development activities with attention to teacher training. The ISCS curriculum group has made a major effort to prepare materials to aid teachers in operating ISCS classrooms.

The ISCS Individualized Teacher Preparation program is described in this paper. Problems related to the design, dissemination, implementation and evaluation of the program are treated. Attention is given to the problem of developing materials that are sufficiently flexible to be used in widely different schools, under a variety of classroom conditions, and with different teacher in-service plans.

CONTRIBUTED PAPERS I

Session A. "Learning Theory and Processes."

Presiding: Paul Beisenherz, Louisiana State University in New Orleans, New Orleans, Louisiana.

1. "Science Inquiry and the Development of Classification and Oral Communication Skills in Inner City Children." Lowell J. Bethel, University of Pennsylvania, Philadelphia, Pennsylvania.

2. "Classificational Preference in Young Children--Form or Color." Douglas R. Macbeth, Lewisburg Area School District, Lewisburg, Pennsylvania.

3. "Relationships of Concrete and Formal Operational Science Subject Matter and the Development Level of the Learner." Anton E. Lawson, Purdue University, West Lafayette, Indiana.

4. "A Comparison of Pictorial and Written Presentation on the Acquisition of Scientific Concepts." Protima Roy and John J. Koran, Jr., University of Florida, Gainesville, Florida.

SCIENCE INQUIRY AND THE DEVELOPMENT OF CLASSIFICATION AND ORAL COMMUNICATION SKILLS IN INNER CITY CHILDREN

Lowell J. Bethel
University of Pennsylvania
Philadelphia, Pennsylvania

Research indicates that many inner city children lack some of the basic skills required for academic success. The major reasons cited for these deficits are the impoverished environment of the inner city child and the lack of experiences common to his suburban counterpart. The purpose of this investigation was to determine the effectiveness of a science inquiry program on the development of two basic skills in inner city elementary school children: abstract categorization and oral communication skills.

Thirty elementary school children participated in a program of thirty one-hour sequential science inquiry sessions in a situation that emphasized resourcefulness and a minimum of constraints. In addition to the materials required for the inquiry sessions, other materials including twelve categorization kits were available to the children. The inquiry materials and school facilities provided the experimental group permitted a broad range of materials for investigation.

The Solomon Four-Group Design was selected for this investigation in order to assess the development of abstract categorization and oral communication skills as a result of experiences acquired in a science inquiry program. One-half of the children from the experimental and control groups were pretested on an individual basis. All children from the experimental and control groups were posttested on an individual basis at the conclusion of the treatment (N=60). The Goldstein-Sheerer Object Sorting Test and the Test of Oral Communication Skills (TOCS) were used in this study as the criterion instruments.

Multivariate analysis of variance tests were used to evaluate the data. The factors of test sequence, treatment, and sex were considered in the analyses. There was a significant improvement in the abstract categorization skills of the experimental group (p=.001). There was a significant improvement in the oral communication skills of the experimental group (p=.001). The experiences acquired by the experimental group through the science inquiry sessions did result in the significant improvement of abstract categorization and oral communication skills.

The inner city child grows up in an environment which may fail to stimulate his abstract and oral communication skills. The development of these skills facilitates the acquisition of other basic intellectual skills. The fact that there was a significant improvement in these skills suggests that an elementary school science inquiry program, based on the manipulation of objects, can be used as a teaching strategy for skills development in inner city children.

CLASSIFICATIONAL PREFERENCE IN YOUNG CHILDREN - FORM OR COLOR

Douglas R. Macbeth
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Lesiwburg, Pennsylvania

The tendency of even young children to group or classify things in their environment is a common observation. The criteria characteristics that are used in making the sortings vary from situation to situation and child to child. Nevertheless, in particular situations, certain of these qualities or factors seem to be used in preference to others. This investigation was designed to test such a preference when the choice factors were color or shape.

The study included over 250 school children ranging in age from three to eight years. The subjects showed typical diversity in academic experiences and intellectual aptitudes. The research procedure involved presenting a subject with a set of colored paper shapes and asking him to sort the objects into subsets. Four different sets of colored paper - cutout shapes were used. The sets consisted of either four or nine members and were to be sorted into two or three subsets, respectively. Following the sorting, the investigator noted the apparent criterion (color or shape) that was used as a basis for making the sort. In those instances where the criterion was not apparent, the youngster was asked the reason for his grouping arrangement. A pilot study had indicated that youngsters generally had a preference to sort by shape rather than color. As a consequence of this observation, some of the four sets were formed in such a way that should discourage a preference to sort by shape. In other sets no such bias was established.

The data consisted of a count of the number of subjects who sorted by shape and those who sorted by color. Comparisons were made between the age and sex of a youngster and his sorting preference. Also, comparisons were made among subject sorting preference on the four different sets. An analysis of the data led to the following conclusions: (1) Youngsters in all age groups tested had a strong tendency to sort colored paper shapes by shape rather than by color, (2) this preference for sorting by shapes was evident for both boys and girls, and (3) even in those sets that were biased against shape as a criterion for grouping, shape was still chosen over color by about two to one.

The findings of this study are dramatic in that they show the strong preference that children have for shape over color as a criterion for classifying plane, colored figures. Although such a preference may not exist in all categorization tasks, it nevertheless has important implications in the development of the classification concept.

RELATIONSHIPS OF CONCRETE AND FORMAL OPERATIONAL SCIENCE SUBJECT MATTER AND THE DEVELOPMENTAL LEVEL OF THE LEARNER

Anton E. Lawson
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West Lafayette, Indiana

This investigation was conducted to find answers to the following questions: What are the levels of intellectual development of selected biology, chemistry, and physics students as determined by Piagetian tasks? What are the major concrete and formal operational concepts taught those students? Are concrete operational students able to understand only concrete concepts while formal students are able to understand both concrete and formal concepts?

Subjects were selected from high school biology, chemistry, and physics classes. They had been taught the normal subject matter by the classroom instructor. During the last month of instruction in the 1972-1973 academic year, 51 biology students, 54 chemistry students, and 33 physics students were interviewed with four Piagetian tasks: Conservation of Weight, Conservation of Volume, Separation of Variables, and Equilibrium in the Balance. Two written problems to assess developmental levels were also administered to groups of students. Comprehensive examinations were constructed which consisted of approximately 15 items to assess understanding of concrete concepts and 15 items to assess understanding of formal concepts. These examinations were face validated by five qualified science educators and administered by the classroom instructors.

On the basis of the Piagetian tasks, 64.8 percent of the biology samplewere categorized as fully or partially concrete operational. The chemistry sample was best characterized as transitional thinkers with 92 percent categorized above concrete operational and below fully formal operational. The physics sample also consisted largely of students operating somewhere above fully concrete and below fully formal operational.

Obtained subject matter examination scores, which were corrected for chance success, indicated that subjects categorized as concrete operational demonstrated understanding of some concrete concepts, however, they demonstrated no understanding of formal concepts. Subjects categorized as transitional to formal operational or above demonstrated understanding of some concrete and some formal concepts. These subjects scored significantly higher ($p < 0.01$) than concrete operational subjects on both concrete and formal concept items.

Multiple correlation coefficients between the Piagetian task scores and the concrete and formal concept scores were significant ($p < 0.05$) for each sample.

Step-wise semi-partial regression analysis of Piagetian task scores indicated the Conservation of Volume and Separation of Variables to be the best predictors of success on the concept examinations. Additional predictor variables were not significant in increasing predictive power.

Principal components analysis of the six Piagetian styled tasks indicated high first component loadings (0.69-0.85) for all tasks.

These results indicate that a substantial portion of secondary school science subject matter is not appropriate in terms of the intellectual level of the learner. A significant portion of the students are still operating largely on a concrete level while science content is largely abstract or formal.

A COMPARISON OF PICTORIAL AND WRITTEN PRESENTATION ON THE ACQUISITION OF SCIENTIFIC CONCEPTS

Protima Roy

and

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University of Florida
Gainesville, Florida

This study was designed to compare the effectiveness of pictorial and written passages on the acquisition of three scientific concepts. Twenty-nine eighth grade science students were randomly assigned to one of three groups: the control group consisted of nine students; the diagram group consisted of ten students; and the written passage group consisted of ten students.

Treatment materials were included in a small booklet. One booklet contained written passages about three scientific (biological) classification concepts. These concepts were tropisms, phyllotaxy and feathers. In another booklet, single line drawings of the same three concepts with appropriate labeling were presented. A pre-test, post-test and retention test was administered corresponding to the content materials. These tests were analyzed and found to be both equivalent and reliable. The reliability coefficient for the test was 0.78 and the mean difficulty was 0.572.

The pre-test was given to all twenty-nine students. After that, the control group was removed from the room and the two treatment groups were administered treatments. All twenty-nine students took the post-test after the treatment. Treatment time and testing time were equivalent for each group. After five days a retention test was administered.

A one-way analysis of variance was used to test the main effects. It was found that student performance on the pre-test was not significantly different. In other words, the groups were equivalent before treatment. The post-test scores showed significant differences ($p < .01$) between the two treatments and the control. Analysis of retention test scores also showed a significant difference ($p < .01$) between the treatments and the control.

It is evident from these results that the treatments made a difference between groups since subjects in each group exhibited greater behavioral change than those in the control group. However, further research and analysis are needed to explore the relative effectiveness of pictorial and written instructional methods for individuals with different characteristics, with different tasks and using different combinations and types of exemplars.

CONTRIBUTED PAPERS I

Session B. Teacher Education

Presiding: Paul Eggen, University of Northern Florida, Jacksonville, Florida.

1. "Understanding the Nature of Science as an Outcome of a Professional Education Course." Edward C. Lucy, Georgia State University, Atlanta, Georgia.

2. "The Effects of Instruction in the Basic Science Process Skills on Attitudes, Knowledge and Lesson Planning Practices of Prospective Elementary School Teachers." Richard L. Campbell, Florida International University, Miami, Florida.

3. "Assessing the Effectiveness of a Competency-Based Physics Program for Elementary Teachers." Glenn Markle and William Capie, University of Georgia, Athens, Georgia.

4. "Effect of Alternative Types of Instruction on the Learning of a Question Asking Skill by Preservice Secondary Science Teachers." Walter Scott Smith, University of Kansas, Lawrence, Kansas.

UNDERSTANDING THE NATURE OF SCIENCE AS AN OUTCOME OF A PROFESSIONAL EDUCATION COURSE

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Atlanta, Georgia

The problem of this study was to investigate certain variables associated with students enrolled in an undergraduate secondary science methods course in order to determine whether the Laboratory Science Program component of the course made a positive contribution to the students' cognitive understanding of the nature of science.

The following two null hypotheses were constructed and tested at the .05 level of significance to guide the analysis and interpretation of the data in conducting a summative evaluation of the Laboratory Science Program:

1. No significant changes will be observed between the students' initial and final understandings of the nature of science for the total sample or when the students are grouped by quarter enrolled.
2. No significant predictors or combinations of predictors for gains in understanding of the nature of science will be observed.

The total sample for this study was composed of 129 students who were enrolled in the course during one of the six consecutive quarters from Winter, 1969 to Spring, 1970. The six consecutive quarter samples contained 20, 24, 26, 18, 24 and 18 students.

The Laboratory Science Program, which made up half of the substantive content of the course, primarily consisted of 39 individualized laboratory activities which required the use of science materials and equipment. The self-contained, packaged, individualized laboratory activities were performed by the students on an open-lab basis. The rationale for the program was the belief that activities which were designed to emphasize either the processes or the products of science would provide a student with a basis for developing his own conceptualization of the nature of science.

The criterion variable on which the summative evaluation of the Laboratory Science Program was based was pretest to posttest gain in understanding the nature of science as measured by the Wisconsin Inventory of Science Processes (WISP). In order to facilitate analysis, the total scale of the WISP instrument was divided into the following three discrete subsets of items: Lower-Order Processes of Science, Higher-Order Processes of Science, and Basic Premises of Science. The WISP instrument was further revised by excluding 15 of the 93 items.

Analyses of variance of WISP pretest scores indicated that there were no significant differences in the initial levels of understanding between students in the different quarter samples. The results of t - tests showed that the variance in the system was unchanged from pretest to posttest administration of the WISP. Analyses of covariance revealed differences between quarter samples in posttest levels of understanding of higher-order processes of science which were not attributable to differences in the students' initial levels of understanding. The results of Tukey and Scheffé multiple comparisons suggested that these differences were most pronounced between Winter 1969 and Winter 1970 quarters. The results of correlated t - tests of WISP gain scores for the total sample exceeded the critical t value on all of the WISP subsets. However, major differences occurred between quarter samples on the subsets. The first three of the six consecutive quarters showed many significant gains. The latter three quarters showed only one significant gain out of a possible eighteen. Up to fifty-six antecedent and transaction independent variables were employed in the step-wise multiple regression analyses computed for the criterion variable. The results of the multiple regression analyses identified several possible WISP gain score predictors. Additional investigations suggested that student gains in understanding the nature of science were predicted primarily by two factors: the number of Higher-Order Processes of Science Activities performed and grade average in the science field of concentration.

THE EFFECTS OF INSTRUCTION IN THE BASIC SCIENCE PROCESS SKILLS ON ATTITUDES, KNOWLEDGE AND LESSON PLANNING PRACTICES OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

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Florida International University
Miami, Florida

The purpose of this investigation was to determine the effects of teaching the basic science process skills to preservice teachers on their (1) knowledge of the process skills, (2) attitudes toward the basic science process skills, (3) selection of process objectives for a science unit and (4) lesson planning practices. A related purpose was to examine the relationship between teachers' open- or closed-mindedness and their use of the basic science process skills.

The subjects in this investigation were preservice teachers ($N = 76$) enrolled in the Professional Year Program during the spring semester at Indiana University. Subjects were randomly assigned to one of two groups. One group was selected as the control group. A second group received the basic science process skills instructional program. Prior to the treatment, both groups received instruction on how to write performance objectives and how to construct science lesson plans. Minimum standards were achieved by all subjects in these two prerequisite skill areas before beginning the study.

The experimental group was given individualized instruction on the basic science process skills while the control group received instruction unrelated to science process skills. Following the treatment, all subjects took an achievement test on the basic science process skills, completed a questionnaire which included 20 objectives from which they were asked to select 10 as those being desirable in a science unit, completed the Rokeach Dogmatism Scale (a measure of open- or closed-mindedness) and prepared a lesson plan consisting of five objectives and an activity for attaining each objective.

From the data obtained in this investigation, it was determined that the treatment group performed significantly better on a process achievement test ($p < .001$), selected significantly more process objectives as those being desirable in a science unit ($p < .05$) and wrote significantly more process activities in their lesson plans ($p < .05$) than did the control group. A significant positive correlation was found among subjects who were considered "open minded" and those who wrote process activities in their lesson plans.

ASSESSING THE EFFECTIVENESS OF A COMPETENCY-BASED PHYSICS PROGRAM FOR ELEMENTARY TEACHERS

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and

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Changing patterns in elementary science curricula necessitate a training procedure consistant with the goals of modern science teaching. The Commission on Science Education of the American Association for the Advancement of Science has described desirable competencies in five areas: scientific inquiry, attitude toward science, the processes of science, scientific knowledge, and continuous learning. Developing these competencies is beyond the scope of a single science or methods course. Consequently, these competencies have been made goals for a series of science courses for elementary teachers.

Physics for Elementary Teachers is one of the series of courses for preservice elementary teachers at the University of Georgia. It represents an attempt to develop knowledge, skills, and attitudes prerequisite to successful elementary science teaching. The course is unique in three aspects:

1. A philosophy of teaching elementary science was considered in its development.
2. The content was selected according to the particular needs of elementary teachers.
3. A self-paced, competency-based, modular format allowed for individual differences in achieving and demonstrating competency.

From the outset three goals were central to the shaping of the physics program. It was intended that the experience would enable students to develop:

1. concepts which express our present understanding of the physical world;
2. proficiency in the use of science processes; and
3. a positive attitude toward science in general and physics in particular.

Four questions were posed concerning the effectiveness of the physics program.

1. Do students enrolled in Physics for Elementary Teachers develop a better understanding of physics related concepts?
2. Do students enrolled in Physics for Elementary Teachers develop a better understanding of science processes?
3. Do students enrolled in physics for Elementary Teachers develop a more positive attitude toward science in general and physics in particular?
4. Do students have a positive reaction to a self-pace, modular, activity-centered, physics program?

The course objectives were used to construct a test of physics knowledge. Application and comprehension were stressed. The Wisconsin Inventory of Science Processes (WISP) and the Welsh Science Process Inventory (SPI) were used to assess understanding of science processes. Subject preference surveys and adjective checklists constructed by the investigators were used to gauge attitudes toward physics, science, and the course.

The course was offered and evaluated during the spring and fall quarters, 1973. The findings of the program assessment were:

1. Scores on the course related physics concepts test increased by an average of eleven points during both quarters.

2. During the spring quarter, scores on the Wisconsin Inventory of Science Processes increased by an average of seven points.

3. During the fall quarter, scores on the Welsh Science Process Inventory increased by an average of five points.

4. Student selections of physics on the subject preference survey increased during both the spring and fall quarters.

5. Student selections of science over non-science subjects increased during both the spring and fall quarters.

6. Student responses on the adjective checklists indicated a positive reaction to the Physics for Elementary Teachers course.

EFFECT OF ALTERNATIVE TYPES OF INSTRUCTION ON THE LEARNING OF A QUESTION ASKING SKILL BY PRESERVICE SECONDARY SCIENCE TEACHERS

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Lawrence, Kansas

The purpose of this investigation was to study the effect that four alternative types of instruction had on the frequency with which high inquiry questions were asked by preservice secondary science teachers in peer microteaching and in student teaching. High inquiry questions asked for comparisons, explanations, inferences, or evaluations.

During their science teaching methods course, subjects (N=62) taught a ten minute peer microteaching lesson prior to (pretest) and immediately following (posttest I) instruction on question asking. Those subjects who continued into student teaching the following semester (N=46) were asked to tape a ten minute segment of one of their typical lessons midway through student teaching (posttest II). The subjects were informed prior to the pretest and posttest I that their question asking would be rated, but they were not informed of what, if any, of their behaviors would be rated in posttest II. The four alternative instructional treatments included (1) reading about typical teachers' questioning behavior, (2) learning to classify questions, (3) planning high inquiry question lessons, and (4) combining both learning to classify and planning.

Compared to the pretest, all instructional groups increased their frequency of use of high inquiry questions in peer microteaching immediately following instruction. The frequency of use of high inquiry questions by all groups was similar in student teaching to that of peer microteaching prior to instruction. However, the four instructional treatments did not have significantly different effects on the frequency with which subjects asked high inquiry questions during either peer microteaching or student teaching.

Since the four instructional treatments had similar effects on increasing the frequency of high inquiry questions asked by preservice science teachers, students or instructors should be able to choose among the four instructional types with the expectation of similar effects on the preservice teacher's question asking, as measured by frequency of high inquiry questions in peer microteaching immediately following instruction.

None of the four treatments caused a significant increase in the frequency of high inquiry questions between the pretest and student teaching. Therefore, if one objective of preservice science teacher education is to increase the frequency of these questions in the student teaching setting, then a plan of instruction, different than the ones investigated in this study, must be pursued.

CONTRIBUTED PAPERS I

Session C. Curriculum Development

Presiding: John Schaff, University of Toledo, Ohio, Ohio.

1. "A Personalized Approach to Teaching Fifth Graders to Design Controlled Experiments." Marcia C. Linn and Herbert Thier, University of California at Berkeley, Berkeley, California.

2. "The Effectiveness of *Science - A Process Approach* in the Development of Problem-Solving Skills in Fifth and Sixth Grade Students." Frank D. Breit and John T. Bullock, University of South Florida, Tampa, Florida.

3. "An Investigation to Determine the Effects of a Science Inquiry Program on the Development of the Skill of Classification of Inner City Kindergarten Children." James F. Galbally, Jr., University of Pennsylvania, Philadelphia, Pennsylvania.

4. "A Comparison of the Montessori Method and *Science - A Process Approach* in the Process of Observation." Joan M. Judge, University of Texas at Austin, Austin, Texas.

A PERSONALIZED APPROACH TO TEACHING FIFTH GRADERS TO DESIGN CONTROLLED EXPERIMENTS

Marcia C. Linn

and

Herbert D. Thier
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Berkeley, California

Educational programs which are responsive to the differences between individuals have frequently been demanded. The Nuffield Junior Science Program developed in England is based on free exploration by each child individually. One purpose of the present study was to determine the effect of a program of free exploration on American upper middle class elementary school students. Various goals for personalized exploration could be set. Inhelder and Piaget have stated that concrete experiences such as those in a personalized program could facilitate the growth of logical thinking. Thus we hypothesized that after an introduction to concepts relevant to scientific investigation, free exploration of materials in an investigation-oriented atmosphere would result in increased ability to analyze and interpret experiments.

Introduction to experimentation was provided in a group setting using the teaching method, concepts, and materials from the Science Curriculum Improvement Study. All students were given the same materials but were encouraged to work with them at their own level. This was followed by the personalized part of the program which involved asking the students what materials they would like to work with, providing these or similar materials, and allowing the students to decide what they wanted to do with the materials.

Four fifth-grade classes in an upper middle class suburban school participated. Two classes participated in the teaching program described above and two had the regular book-oriented science program. All teaching was done by a member of the project staff. Experimental and control classes had comparable IQ and achievement test scores. Three forms of a test to measure knowledge of variables and ability to analyze and interpret experiments were developed. One form was administered before teaching began, one form after the group teaching, and one form after the personalized program.

At least three project staff members were present during each science session. Staff observations as well as records of which materials each student used, and reports by students of their experiments gave information on how the program worked in the classroom.

Response to the group teaching was typical of this sort of student--interest and cooperation were high.

Response to the personalized program differed from descriptions of the autonomous student work described for Nuffield Junior Science in Britain. From the beginning, students looked to their peers for guidance. Although twenty-three projects were available and students were told that the experimenters would bring any additional materials that were requested, students tended to work on the same thing. Thus, at any one class meeting, most of the students were using two or three projects. Other evidence of peer orientation included observations that students consulted each other on what experiment to do next, how to use the materials they had chosen, how many reports to write, and what form to use for recording observations.

Besides the peer orientation noted above, students frequently sought out the staff members for guidance. Questions about what experiment to do, how to record data, and how to write reports were frequent. Staff members attempted to help by finding out what the student was interested in doing rather than by telling the student what to do.

Results of the tests of science processes indicated 1) that students had made significant progress on naming variables after the group teaching and after the total program, and 2) that significant progress on ability to analyze and to interpret experiments resulted from the total program.

THE EFFECTIVENESS OF SCIENCE - A PROCESS APPROACH IN THE DEVELOPMENT OF PROBLEM-SOLVING SKILLS IN FIFTH AND SIXTH GRADE STUDENTS

Frank D. Breit

and
John T. Bullock
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Attempts to measure the effectiveness of the newer elementary science programs in developing problem-solving skills have been generally inconclusive. Two major factors appear to prevent the establishment of conclusive evidence regarding this matter. One factor is the lack of valid and reliable instruments for measuring problem-solving skills in students of elementary school age. Another factor appears to be the lack of studies which investigate the effect of a program on problem-solving skills over a sufficient time span. Thus, the implementation of research studies utilizing new measures of problem-solving ability and long range time intervals would seem to be essential for a determination of the effectiveness of the new elementary science programs in attaining one of their major goals; the development of scientific inquiry or problem-solving skills.

The objective of this study is to determine the long term effect of the instructional program Science - A Process Approach on the attainment of certain selected problem-solving skills. The study utilizes a causal comparative design. A comparison was made of the performance on certain specified problem-solving skills of two groups: children who have been involved in the instructional program Science - A Process Approach for a period of four to five years, and children who have not had any direct involvement with Science - A Process Approach.

The sample was drawn from all of the fifth- and sixth-grade students in Hillsborough County, Florida. The sampling procedure included a deliberate sampling technique. Two groups have been selected from 80 schools. One group consisted of students who have been in classrooms using Science - A Process Approach for at least four years. The second group consisted of students who have been in classrooms not using Science - A Process Approach. A random sample of 100 was selected from each of these groups and utilized in the study.

The TAB Science Puzzler, Form B., was administered to test the hypotheses of this proposal. This test is designed to measure student skill in selected problem-solving skills. Numerous data are reported regarding the use of this test in the literature in terms of its proposed use in this study. The test was administered during the fall of 1973.

An analysis of covariance technique, consisting of regression prediction and then an analysis of variance procedure, was used to test for mean differences between the groups and will be reported as an "F" statistic. Computer program BMD04V was used to compute the analysis of covariance using the battery of test scores (available in student folders) as the covariant and by using *TAB Science Puzzler* scores as the dependent variable.

Analyses of the results make it possible to determine the relative abilities of two groups of students to perform the problem-solving skills identified on the *TAB*. From this, inferences are drawn concerning the long term effect of *Science - A Process Approach* on the attainment of the identified problem-solving skills.

AN INVESTIGATION TO DETERMINE THE EFFECTS OF A SCIENCE INQUIRY PROGRAM ON THE DEVELOPMENT OF THE SKILL OF CLASSIFICATION OF INNER CITY KINDERGARTEN CHILDREN

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Philadelphia, Pennsylvania

The purpose of this study was to determine the effectiveness of a science inquiry program on the development of the inquiry skill of classification in inner city kindergarten children.

Eighty-two kindergarten children from an inner city school were randomly assigned to an experimental or a control group. The experimental group participated in a science inquiry skill development program consisting of twenty sessions. Each session was twenty minutes long and the treatment extended over a six-week period.

The Solomon Four Group Design was used in this study because of its appropriateness to developmental studies. One-half of the children from the experimental and control groups were pretested. All of the children from each group were posttested. The Sigel Object Categorization Test was the criterion instrument used in all testing.

Multivariate analysis of variance was the statistical test used in the analysis of posttest data. The factors of treatment, sex, and prior testing were considered in the analyses. There were no significant sex or prior testing effects. Treatment effects were significant. It was concluded that a science inquiry program was an effective means of facilitating the classification development of inner city kindergarten children.

Classification is one of the basic inquiry skills of science. The development of this skill facilitates the acquisition of other inquiry skills. The fact that increased competence in the ability to classify is exhibited by inner city kindergarten children after participation in a science inquiry program suggests that experiences can be provided to effectuate classification development. This result is consistent with other studies aimed at remedying inquiry skill deficits in inner city children. It also points out the feasibility of using this type of instructional strategy and program with kindergarten children.

A COMPARISON OF THE MONTESSORI METHOD AND SCIENCE - A PROCESS APPROACH IN THE PROCESS OF OBSERVATION

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Similarities found in Science - A Process Approach and the Montessori method are a sequential approach, the use of materials for sensory training, practice acquired through activities, and the role of the teacher. These common elements were compared in the context of the process of observation in the two programs. All the lessons of the observation hierarchy for Part A in Science - A Process Approach were found in the Montessori method with the exception of two lessons. From the assumption that the two programs had similar approaches in teaching the process of observation, the question that was raised was whether Montessori preschool children would do as well as preschool children trained in Science - A Process Approach.

The Science Process Instrument (SPI), an individualized test, was used to compare the competence in the process of observation of Montessori preschool children and preschool children trained in Science - A Process Approach. The observation section of the test was comprised of sixty-eight tasks to measure the competence level of the process of observation. These observation tasks were arranged in a sequential order following the observation hierarchy of Science - A Process Approach. The SPI was individually administered to 75 preschool children divided into three groups: (1) Montessori preschool children, (2) Science - A Process Approach preschool children, and (3) non-Montessori/non-Science - A Process Approach preschool children (control group).

In this study, the Montessori preschool children did as well as the Science - A Process Approach preschool children in completing the observation tasks. The mean scores of the highest level achieved on the SPI was 26.52 for the Montessori group and 26.40 for the Science - A Process Approach group. A t - test indicated no significant difference between the two groups. The preschool group who had neither Montessori nor Science - A Process Approach training did not achieve as well as those who had training. Their mean score from the SPI was 12.64. A significant difference was found in comparing the control group with the Montessori group by means of a t - test. A significant different was also found between the control group and children trained in Science - A Process Approach. This study indicated that the process of observation is not unique to Science - A Process Approach and that this process skill is taught in the Montessori method, also. Another finding was that observation skills are not a result of regular preschool but that they need to be specifically taught in a sequential order.

CONTRIBUTED PAPERS I

Session D. Instructional Procedures

Presiding: Stanley L. Helgeson, The Ohio State University, Columbus, Ohio.

1. "The Effectiveness of the Concept/Process Section of the Assessment Instrument for the Science Curriculum Improvement Study Unit Entitled 'Organisms'." Glen R. Perry and Dale G. Merkle, Shippensburg State College, Shippensburg, Pennsylvania.

2. "A Preliminary Study of Using Interactive Instructional Television to Promote Statewide Process-Oriented Science in Primary Grades, or 'Team Teaching With a Television Set Can be a Shocking Experience'." Michael Szabo, Dorothy Alfke, Robert Shrigley and Paul Welliver, The Pennsylvania State University, University Park, Pennsylvania.

3. "Science Teaching and Language Usage in Elementary School Classrooms." Glenn W. Clark, University of Kansas, Lawrence, Kansas.

4. "The Effects of Instruction in the Concept of Speed and Simple Proportions on Children in the Third Grade." F. David Boulanger, University of Illinois, Chicago, Illinois.

THE EFFECTIVENESS OF THE CONCEPT/PROCESS SECTION OF THE ASSESSMENT INSTRUMENT FOR THE SCIENCE CURRICULUM IMPROVEMENT STUDY UNIT ENTITLED "ORGANISMS"

Glen R. Perry

and

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The effectiveness of the assessment instrument for the SCIS "Organisms" unit was accomplished by examining the content validity and reliability of the measure. Also, a t-test was applied to the gain scores of the students to determine if there was a significant positive change in pupil performance as a result of instruction in the "Organisms" unit. Possible differences in performance between urban and rural students were also examined.

The Concept/Process section of the instrument was administered as a pretest and a posttest to first grade students in rural and urban groups. Both measures were administered by the researcher. Students were removed from the classroom for testing. Activities one, two, and five of the instrument were administered individually to students in the sample group. Activities three and four were administered as group tests to each of the eight groups of students. Only one evaluative activity was administered to the students in a given sitting.

After pretesting, the teachers began instructing the students in the "Organisms" unit. As each section of the unit was completed, teachers contacted the researcher and a time was arranged to administer the corresponding section of the posttest.

The sample was limited to first grade students who were receiving instruction in the SCIS program. Five boys and five girls were selected at random from the first grade classes of eight elementary schools in the district.

Four of the cooperating schools were in urban locations; four others were considered to be in rural communities near the city.

The Concept/Process section of the assessment instrument was found to have content validity and reliability. The test items are compatible with the instruction described in the "Organisms" Teachers' Guide. A reliability coefficient of .577 was obtained using the Spearman-Brown formula.

Significant positive change in pupil performance as a result of instruction was found. The gain scores for the students were subjected to a t-test at the .05 alpha level. The calculated value for t of 35.1 was significant.

No pretest or posttest differences were found when examining urban versus rural populations.

The researcher concluded that the "Organisms" assessment instrument is effective in terms of content validity, reliability, objectivity and interest. The students retained a high degree of interest throughout the testing program.

The first four activities of the assessment instrument can be considered objective in nature. However, the fifth activity requires subjective judgment on the part of the evaluator. First grade students could be expected to have difficulty in hypothesizing, interpreting data, and constructing experiments, and they did.

One of the basic assumptions of this study was that the materials in the "Organisms" unit were child centered, therefore teacher differences were not important. The unit is not teacher-proof, nor school district-proof. Reluctance to teach certain concepts, fear of animals, and poor supply programs caused many problems. An in-service program to improve teacher backgrounds in science and techniques of science instruction could reduce many of the problems encountered. A science coordinator could greatly improve communication and maintenance of science materials.

A PRELIMINARY STUDY OF USING INTERACTIVE INSTRUCTIONAL TELEVISION TO PROMOTE STATEWIDE PROCESS-ORIENTED SCIENCE IN PRIMARY GRADES OR

TEAM TEACHING WITH A TELEVISION SET CAN BE A SHOCKING EXPERIENCE

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Science educators have long been aware of difficulties in successfully implementing process-oriented science activities in elementary grade classrooms. The problem is greatly magnified if the curriculum is to be adopted on a state, regional, or national basis.

This paper presents preliminary findings of a statewide project to implement a process-oriented project in elementary schools in Pennsylvania (Science for the Seventies; SFTS) not served by some process-oriented curriculum. A related purpose of the project was to promote selected process-oriented behaviors on the part of teachers and students.

A series of ten televised programs, each correlated with a specific SFTS lesson, was developed for broadcast television. The ITV programs are unique in two respects. First, they are designed to lead a teacher and class into the appropriate SFTS lesson. Second, they are interactive in the sense that the teacher teams with program to encourage student investigation. For example, to accomplish this interactive effect, in one sequence the announcer asks "What words would you use to describe this object?" At this point in the lesson on Observation and Description, the audio becomes silent and the teacher continues the interaction.

The intent of the interactive approach is to encourage the teacher to model those behaviors which promote science process utilization by student and teacher.

Fifty primary grade teachers from Central Pennsylvania volunteered to test four or more of the program/lesson combinations in their own classrooms during the Spring of 1973. Evaluation questionnaires were completed for each program used. A geographically-convenient subset of the teachers (N=30) was observed and their verbal behaviors coded during the ITV program and the followup SFTS lesson.

Using a Likert-type response format questionnaire, teachers reported feeling a bit apprehensive about this unfamiliar technique. Although understandable (no training other than reading the manual was provided), the apprehension quickly disappeared. Many noted that the "team-teaching was the easiest part of the experience." They were also enthusiastic about the amount of student interest and participation generated. A toll free telephone line to provide direct contact with staff personnel was never used, although local administrators were pressed into service to provide equipment.

Responses further suggest that the teachers 1) felt both student and teacher learning had taken place, 2) considered the materials well-done and appropriate; 3) consciously attempted to incorporate those teaching methods or process skills modelled during the program directly into the lesson; 4) preferred interactive ITV to other modes of subsequent instruction; and 5) stated a desire to use the series with in-service programs.

Teacher verbal behaviors during the interactive program were coded live by trained observers. Questions requiring memory constituted only 10 percent of the total teacher questions across programs; thinking questions accounted for 90 percent. These figures compare most favorably with research summaries citing 20 percent thinking questions and 60 percent memory questions by teachers (Gall, 1970).

During the followup lessons, 40 percent of the questions required memory and 60 percent required thinking, suggesting some carry-over of the behaviors modelled earlier.

It was concluded that unobtrusively leading teachers to model desirable science teaching behaviors can result in their actual implementation with positive affective results.

SCIENCE TEACHING AND LANGUAGE USAGE IN ELEMENTARY SCHOOL CLASSROOMS

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Science in the elementary school is a neglected area for many reasons. One of the major causes of this problem, as any veteran teacher will tell you, is that no time exists for science teaching once the demands of teaching language arts and math have been met.

The view exists that areas such as science can be passed over in the primary years until skills have been developed. These ideas have persisted despite theoretical positions indicating that language and language use is best learned in situations where language and action are required.

This paper reports a first attempt at relating language usage and language development to the teaching of science in the classroom.

Seven teachers were given four months training in science teaching and in the use of question asking techniques to be used in science classes. These teachers began teaching some science early in their training and continued throughout the experiment. After this training, tapes were taken in the classrooms of these teachers and those of an equal size control group during (1) a prescribed science lesson and (2) a lesson chosen by each teacher to be "typical of discussion in your classroom."

The collected tapes then served as information for data analysis. Once the tapes had been transcribed, teachers' questions in science lessons were categorized into one of four categories. Student responses in all lessons were analyzed for syntactic level by finding the mean terminal syntactic unit (t-unit) for each classroom. (This unit is approximately equivalent to sentence length.) Pre- and post-language achievement test scores were also collected.

No differences were found between science and non-science classes or between experimental groups on syntactic level of student responses. Within the science classes, significant differences in syntactic level were found for different types of teacher questions, with higher cognitive levels of questions receiving syntactically more complex responses. Also, experimental teachers were found to ask significantly more higher level questions than did control teachers. Finally a significant partial correlation between mean t-unit in classrooms and posttest language achievement scores was obtained, with the effect of the pretest partialed out.

Taken together, these results do not show an advantage in language usage in science classes. What they do show is that language usage on a verbal level in the classroom has a strong effect on language achievement tests of students. One encouraging result in science was that strong gains were made by the experimental teachers in asking higher levels of questions. Further research in this area could probably be done profitably if emphasis were put on increasing the level of language within science rather than in making comparisons between subject areas.

THE EFFECTS OF INSTRUCTION IN THE CONCEPT OF SPEED AND SIMPLE PROPORTIONS ON CHILDREN IN THE THIRD GRADE

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Piaget claimed that the concrete operational child is incapable of using quantitative proportional reasoning since he has not developed the formal operational schema of proportions. However, training studies raised questions about the extent to which Piagetian schemas may be activated via instruction. The purpose of this study was to investigate the effects of systematic instruction in the concept of speed and simple proportions on the performance of concrete operational children in the third grade.

A screening test was administered to select a population of children from six third grade classrooms (three elementary schools) who could perform simple division and who were concrete operational in their conception of space, time and speed. Fifty-one children were randomly selected from those who met the screening test criteria. They were randomly assigned to two instructional groups and a control group.

One instructional treatment (Training and Comparison Treatment) was a sequence of problems, questions, and demonstrations interwoven with training in the concept of speed and simple proportions. The objective of the treatment was to train the child to solve speed comparison problems which Piaget claimed required the use of formal operational proportions.

The other instructional treatment (Comparison Only Treatment) was the same as the Training and Comparison Treatment, but without specific training in the concept of speed and simple proportions.

All instruction and testing was done individually. The Control group received no instruction. The dependent measures of retention, transfer, and transfer to two Piagetian tasks were administered immediately after the instructional treatment and again (similar forms) three weeks later. The analysis of variance was applied to the data. Alpha was set at .05.

The major findings were:

1. The Training and Comparison treatment group scored significantly higher ($p < .01$) than the Control group on the immediate retention measure. However, this difference fell below the significance level on the delayed retention measure.

2. Each treatment group scored higher than the Control group on both immediate and delayed transfer measures, but the difference failed to reach significance ($p < .07$ on immediate transfer and $p < .06$ on delayed transfer).

3. There were no significant differences among the three groups on either administration of the first Piagetian task (application of proportions).

4. The Control group scored significantly higher ($p < .01$) than the Training and Comparison group on the immediate administration of the second Piagetian task (application of compensatory operations). However, this difference fell below the significance level on the delayed administration of the same task. Apparently, the more highly focused and specific the training, the more hinderance it was to the performance of a remotely related motion task.

This study demonstrated that concrete operational children in the third grade can be trained to retain, on an immediate basis, simple proportion tasks. However, the study failed to demonstrate any general or long term activation of the schema of proportions.

CONTRIBUTED PAPERS I

Session E. Evaluation

Presiding: James J. Gallagher, Governors State College, Park Forest South, Illinois.

1. "An Interaction Between Student Traits and Methods of Teaching College Physics." Mary E. Diederich Ott, Cornell University, Ithaca, New York.
2. "Change in Teacher Classroom Behavior Following Involvement in Summer Institute Science Content Courses Where Instructors Conveyed Methodology by Modeling." Susan D. Spradlin, Austin Community College, Austin, Texas.
3. "The Effects of an Earth Science Curriculum Revision on Teacher Behavior and Student Achievement." James R. Orgren, State University College of New York at Buffalo, Buffalo, New York.
4. "The Attitudes of High School Biology Teachers to the BSCS Program in Israel." Pinchas Tamir, The Hebrew University of Jerusalem, Jerusalem, Israel.

AN INTERACTION BETWEEN STUDENT TRAITS AND METHODS OF TEACHING COLLEGE PHYSICS

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Frequently, comparisons of student achievement in two or more instructional treatments are reported to result in no significant differences between treatments. However, as has been emphasized recently, in such studies one also ought to look for interactions between student traits (including aptitudes) and treatments (e.g., instructional methods). If interactions are found, one treatment may be better for some students having certain levels on the trait in question, and the other treatment may be better for students having other levels on that trait. It is clearly important to identify such interactions so as to guide faculty and students in selecting instructional methods.

We used a trait-treatment interaction approach to analyze the achievement of first year college physics students in two instructional treatments -- an audio-tutorial treatment, and a lecture-recitation-laboratory treatment. We found evidence for a disordinal interaction between mathematical aptitude (as measured by the mathematics portion of the Scholastic Aptitude Test), achievement in mathematics (as measured by a pre-test of our design), and the treatments. The dependent variable was the students' achievement in the course as measured by course final grade.

The standard method included two hours of lecture and two hours of recitation per week, and a two-hour lab every second week. The audio-tutorial method included one hour of recitation per week, in addition to learning center activities.

The multiple regression equations relating predicted final grade to levels on SATM and to scores on the math pre-test differed in the two treatments. We analyzed the interaction using the Johnson-Neyman technique, in order to determine whether there were levels on the traits which predict greater success in either treatment. The results were as follows: at the .10 level of significance, the standard treatment was preferable to the audio-tutorial treatment in terms of expected achievement for students with perfect scores on the math pre-test and SATM scores greater than or equal to 725. The audio-tutorial treatment was preferable for students with low math pre-test scores and SATM scores less than 625.

We concluded that the observed interaction was probably due to inherent characteristics of the two treatments, such that one was more suitable for students with the highest mathematical ability and achievement, and the other more suitable for students in the course with the lowest mathematical ability and achievement. The greater degree of individualization in the audio-tutorial treatment seemed to benefit lower ability and achievement students relative to similar students in the standard treatment. The greater amount of time allocated to recitation in the standard treatment, and the emphasis in recitation on problem solving, may have accounted for the greater achievement of higher ability and achievement students in the standard treatment relative to similar students in the audio-tutorial treatment.

CHANGE IN TEACHER CLASSROOM BEHAVIOR FOLLOWING INVOLVEMENT IN SUMMER INSTITUTE SCIENCE CONTENT COURSES WHERE INSTRUCTORS CONVEYED METHODOLOGY BY MODELING

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The vital teacher-student interaction as reflected by teacher classroom behavior is rarely a part of either inservice education programs or their evaluations. Little has been done to measure the effectiveness of such programs as they relate to change in teacher classroom behavior. Most institutes offer content courses to improve teacher subject competencies, thus, teaching techniques must be introduced informally, as, for example, by modeling the strategies while teaching the course.

The purpose of this study was to ascertain to what degree the use of modeling techniques during content presentation could be shown to have worked to alter teacher classroom behavior in the desired direction.

Data were collected from more than 1100 students in the classes of 47 of the participants in the Summer Institute Programs offered by The University of Texas at Austin in 1971 and 1972. Of the teachers used, 18 taught earth science; 15, physical science; and 15 taught biological science. Each taught in his area before and after the institute and was enrolled in the corresponding institute content course. These content courses were:

PHYSICAL SCIENCE. The course was built around the Texas Education Agency's Physical Science Resource Guide and stressed student operational understanding of concepts through laboratory exercises. The instructor was familiar with modeling the student-oriented, laboratory-centered teaching approach.

EARTH SCIENCE. This course was based on ESCP's Investigating the Earth. The instructor was well versed in modeling the proper use of materials in a student-laboratory-centered teaching approach.

BIOLOGICAL SCIENCE. Based on ecological problems presented by lecture and independent study projects in 1971, the 1972 course lectures covered a wider range of topics. The BSCS Laboratory Block: Plant Growth and Development was used for the laboratory section during both years.

Measurements were made in April of the years preceding and following institute participation. Each teacher selected one class at that time and gave them the Science Classroom Activity Checklist (SCAC). The pre- and post-treatment scores were then compared to determine change and its level of significance.

Combined data were tested by one-group-two-trials analysis of variance. Significant changes ($p = .05$) were found in all seven subscales plus the total score of the SCAC.

When grouped by subject area and tested by three-groups-two-trials analysis of variance, the results indicated the following specific areas of change following the institute:

1) Earth science teachers allowed more student class participation (Subscale B, $p = .017$), used the text as a source of problems and answers (Subscale C, $p = .013$), followed up laboratory exercises by comparing and graphing student conclusions (Subscale G, $p = .037$), and were more student-centered in general (Total score, $p = .001$).

2) Physical science teachers tested equally on laboratory exercises and class discussions (subscale D, $p = .013$), spent more time discussing future laboratory problems and possible solutions (Subscale E, $p = .021$), used more open-ended laboratory exercises (Subscale F, $p = .038$), followed up by graphing and comparing all data (Subscale G, $p = .003$), and in general were more laboratory and student-centered (Total score, $p = .004$).

3) Biological science teachers made no changes significant at the .05 level.

THE EFFECTS OF AN EARTH SCIENCE CURRICULUM REVISION ON TEACHER BEHAVIOR AND STUDENT ACHIEVEMENT

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Between 1958 and 1970, science education was radically affected by a new mode of science curriculum development, stimulated and largely funded by the National Science Foundation. Many new science curricula, such as PSSC physics, CHEM Study chemistry, BSCS biology and ESCP earth science were produced by NSF funded curriculum development committees. It has been shown that little overall evaluation of curriculum effectiveness was undertaken by the various curriculum development projects. Although the new curricula sought to modify teaching behaviors to include more laboratory methods, and to promote more inquiry on the part of the students, changes in teaching behavior that could be attributed to adoption of one of the new science curricula have been very lightly researched.

The present study sought to determine the effects which adoption of the 1970 revision of the New York State Regents Earth Science Syllabus had on several teacher and student variables. The primary focus of the study was on changes in teaching behavior which may be attributed to the adoption of this new science curriculum.

Three samples of classrooms were selected for the study:

A. Group A, consisting of classrooms whose teachers chose to continue teaching the traditional syllabus in 1970, when the revised (laboratory and inquiry oriented) syllabus was offered for voluntary adoption; these teachers adopted the new syllabus in 1971, when its adoption was mandatory.

B. Group B, consisting of classrooms whose teachers elected to begin teaching the new syllabus in 1970.

C. Group C, consisting of classrooms whose teachers had prior experience with the new syllabus during the period of its development (1966-1970), and who were continuing to teach the new syllabus in 1970.

Data were gathered from approximately thirty classrooms in each group between the fall of 1970 and the spring of 1972.

Multi-variate analysis on a two-way factorial design (groups by time) showed that Group A differed significantly from Groups B and C with respect to teaching strategies employed, teacher educational opinion, student achievement on tests measuring student knowledge with respect to each of the syllabi, and student performance on a test of the ability to employ the processes of science. Group B did not differ significantly from Group C with respect to any of the above variables. Analysis of the difference from one year to the next showed that the significant year to year change occurred in the teaching strategies of Group A teachers. Reference to the mean scores indicated that all of the significant differences were in the predicted direction.

Teaching strategies employed by Groups B and C were more laboratory and inquiry oriented than were those of Group A. Group A, however, began to employ significantly more inquiry and laboratory oriented teaching behaviors when they began using the new syllabus in 1971. Group C expressed more progressive educational opinions than did Groups A and B. No groups significantly changed their educational opinions during the course of the study. In 1971, students in Groups B and C did significantly change their educational opinions during the course of the study. In 1971, students in Groups B and C did significantly better on a "new content" test than did students in Group A. Students in Group A, however, did significantly better than students in the other two groups on a test on the "old content." In 1972, when all groups were using the same syllabus, there were no significant differences between any of the groups with respect to performance on either content test. Improvement in ability to employ the processes of science did not differ significantly among the students in the three groups, in either year of the study.

It appears from this study that teaching strategies employed under the old curriculum and new curriculum differ. When teachers change to the new curriculum, they change their teaching strategies, but not their educational opinions. Teachers who participate in the development of a new science curriculum seem to hold educational opinions which significantly differ from those held by the general population of science teachers.

Student achievement on tests of earth science content seems to be specific to the earth science teaching materials employed. There appears to be no advantage to learning under either curriculum, as far as improvement in ability to employ the processes of science is concerned.

THE ATTITUDES OF HIGH SCHOOL BIOLOGY TEACHERS TO THE BSCS PROGRAM IN ISRAEL

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The purpose of this study was to determine the attitudes of high school biology teachers to the BSCS program in Israel. It was assumed that teachers' attitudes concerning curricular materials must be considered if successful implementation of these materials is to be achieved.

An Attitude Inventory toward the BSCS biology, developed by Blankenship in the United States and validated there by him and by others was translated into Hebrew and used in the present study. This instrument consists of 46 statements half of which were judged to be in agreement with the BSCS rationale and philosophy while the other half were judged to be in disagreement with them. The Inventory was mailed to 200 high schools all over the country, representing all types of high schools in Israel with a request that the biology teachers respond. One hundred and eleven complete inventories were returned by mail adequately representing the three alternative curricula used in Israel, namely BSCS (64 percent), traditional (20 percent), and a mixed program using some traditional and some BSCS materials (16 percent). They also consisted of a representative sample of teachers regarding sex (53 percent males), as well as the different types of schools in the country (agricultural 19 percent, rural - kibbutz 24 percent, comprehensive 23 percent, city academic 24 percent).

The mean scores of the different groups on the Inventory were compared by t-tests. The percentage scores on the individual items were compared by Chi-square.

The major findings are as follows:

a. The Blankenship Attitude Inventory successfully differentiated between teachers of favorable and those of unfavorable attitudes toward the BSCS program in Israel.

b. Teachers who taught the BSCS course had significantly more favorable attitudes toward the philosophy and rationale of the BSCS than those who used traditional materials. Moreover, the more experienced the teachers were in teaching the BSCS, the more favorable their attitudes were toward the program.

c. Although the adoption of the BSCS course in Israel was on a voluntary basis, some teachers who taught the BSCS course held unfavorable attitudes toward certain components of the BSCS philosophy.

d. There were some significant interactions between the school environment and the attitudes of teachers toward the BSCS. For example, the BSCS program was most highly regarded by teachers in rural-kibbutz school and least highly regarded by teachers in city academic schools, the latter found it very difficult to teach an inquiry oriented course under the constraints of their school environment.

e. Male teachers, on the average, were more willing than female teachers to teach biology by inquiry and to build their courses based on the students' work in the laboratory.

f. The study revealed that most teachers found certain weaknesses in the BSCS program. For example, even the BSCS teachers did not believe that the BSCS Yellow Version adequately provides for differences in students' ability.

The following implications were warranted by the findings: Special care should be taken in order to ascertain that a new curriculum to be adopted can be taught under the specific local conditions. Teachers who adopt a new curriculum need an adaptation period during which they learn to handle the materials and to overcome emerging difficulties, thereby acquiring more faith in and more comfort with the new program. Special efforts are needed to explain the rationale and philosophy of the program to the teachers. It is highly improbable that teachers who teach the BSCS course and still hold unfavorable attitudes toward its philosophy will use the type of instruction advocated by the BSCS. Special efforts are needed to change such unfavorable attitudes, or alternatively, it is suggested that teachers who still maintain unfavorable attitudes, as measured by the Attitude Inventory, will not teach a BSCS-type course.

CONTRIBUTED PAPERS I

Session F. Research Methodology

Presiding: Mary Budd Rowe, University of Florida, Gainesville, Florida.

1. "The Mathematics Skill Test, MAST as Rostering and Diagnostic Tools." Rita T. Denny, University of Pennsylvania, Philadelphia, Pennsylvania.

2. "An Application of Fishbein's Regression Model to the Prediction of Behavioral Outcomes of Instruction." Kenneth H. Abramson, Cook Elementary School, Vancouver, B.C. and Walter B. Boldt, University of British Columbia, Vancouver, B.C.

3. "Managing Misbehavior in the Science Classroom: The Development of a Written Measure." John T. Wilson, University of Iowa, Iowa City, Iowa.

4. "Processes of Curriculum Development - A Neglected Research Area." David Cohen, Macquarie University, New South Wales, Australia.

THE MATHEMATICS SKILL TEST,

MAST AS ROSTERING AND DIAGNOSTIC TOOLS

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The Mathematics Skill Test (MAST) is a 60-item 45-minute power test designed to show a student's basic competence in 10 mathematics skills needed to succeed in high school chemistry. Concurrent reliability was demonstrated in 1970 with Philadelphia high school students ($r = .967$; test reliability $= .8$; $n = 242$).

Could MAST be useful in describing a math profile for each student prior to the student's enrollment in chemistry? Could MAST be a useful rostering tool for chemistry enrollment?

In April, 1972, an investigation began to establish predictive validity of MAST. High schools having a variety of student achievement and background were needed. Two high schools agreed to participate, one in Nashville, Tennessee, and one outside Boston. All students eligible for chemistry enrollment for the following September took MAST in May, 1972. Those scoring above one standard deviation from the mean were grouped in advanced chemistry. Only those scoring above the mean could elect a quantitative or qualitative chemistry course. Math remediation was suggested for those scoring between the mean and one standard deviation below the mean. Those scoring below one standard deviation from the mean were advised not to take chemistry.

At the end of the first year chemistry course in May, 1973, chemistry success was compared with MAST success to establish a predictive validity for MAST. Chemistry courses for the Nashville group of 84 were varied in goal definition so that one objective standardized test was not considered an appropriate means of chemistry evaluation. For this group, MAST scores were correlated with chemistry grades ($r = .356$; significant at .05 level).

The 1969 ACS-NSTA High School Chemistry Test was given to all the students in the Boston group ($n = 188$). ACS scores were correlated with MAST scores, (MAST total score and ACS raw score, $r = .731$; significant at .01 level).

The empirical data supported MAST as an effective predictor of chemistry achievement, as a rostering tool and as a diagnostic tool for individualizing each student's work in chemistry. MAST was used to indicate which students would profit by an accelerated course or by math remediation. MAST established an objectively-defined Math baseline for students prior to their encountering math difficulty in chemistry.

AN APPLICATION OF FISHBEIN'S REGRESSION MODEL TO THE PREDICTION OF BEHAVIORAL OUTCOMES OF INSTRUCTION

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Can behavioral intention and actual performance of voluntary extracurricular activities be predicted with better than chance accuracy? Which components of the model, attitudinal or normative, serve as the best predictors? Answers to these questions were sought in connection with a module of instruction on physics and environmental problems in a first-year course in college physics for non-science students at the University of British Columbia in 1972-73.

Five extracurricular activities, ranging from picking up literature on environmental problems to becoming actively engaged in research projects on pollution being conducted by scientists, were presented as free-choice options to students taking the module.

At the end of the second last lecture in the module, 128 out of 185 students were given an instrument for obtaining scores on behavioral intention with respect to each of the activities. Included in the instrument were scales for obtaining scores on attitude toward engaging in each of the activities and scales for obtaining scores on the normative beliefs of the students, i.e., indicants of their perception of what they believe the expectations of others, and themselves, are with respect to becoming involved in each of the activities. Additional scales were included to get a measure of their motivation to comply with these expectations.

Fifty-seven students in the class received an instrument for obtaining attitude scores on various aspects of the course, as opposed to attitude scores on performing an activity. The scores obtained by this instrument were used to check Fishbein's conjecture that variables not included in the model will only be good predictors of behavior if they are significantly correlated with the variables of the model serving as good predictors.

The results obtained were encouraging. Predictions of behavioral intention for three out of five activities were considerably better than chance. Multiple correlations ranged from 0.71 to

0.80 for these activities. The best predictor of behavioral intention across these activities was the personal normative belief component of the model, although the attitudinal component contributed significantly to the predictions as well.

Better than chance predictions were also obtained for actual involvement in two out of the three activities investigated in this way. However, significant multiple correlations were considerably lower, varying from 0.33 to 0.38. The best predictor of actual behavior too, was the personal normative belief factor. The attitudinal factor in this case did not significantly improve prediction.

Fishbein's model for predicting behavioral intention and overt behavior can provide the teacher with a systematic way of predicting behavioral outcomes of instruction and, in addition, suggests what the most important predictors are. Since variables not included in the model, e.g., attitude toward various aspects of the course, did not have significant predictive value unless they were significantly correlated with the important predictors of the model, the teacher using the model has fewer variables to contend with. Further studies are needed to extend this potentially useful model to a wider range of school situations.

MANAGING MISBEHAVIOR IN THE SCIENCE CLASSROOM:

THE DEVELOPMENT OF A WRITTEN MEASURE

John T. Wilson
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A sample of 25 inservice and preservice science teachers were administered an instrument constructed to provide evidence of a science teacher's competency to desist and manage misbehavior relative to various science classroom activities. The instrument included a description of a specimen science classroom and member students, the type of classroom activity utilized, and thirty instructive incidences common to junior high science classes. The teacher examinees were to respond to each incident by reporting all that they might say or do in each case. Their responses were then rated by three raters using categories of teacher desist behavior and management strategies. The results indicated that desist and management skills of the science teachers examined varied both in the number of categories performed and the frequency within each category ($p < .05$). Research evidence suggests that effective management and desisting is dependent upon an adequate repertoire of teacher behaviors and skills. In view of the reliability of the instrument (interrater agreement = .78), the instrument may be useful for identifying those teachers who may have only a limited repertoire of skills and therefore may have problems managing the diverse types of activities common to contemporary science classrooms.

PROCESSES OF CURRICULUM DEVELOPMENT -
A NEGLECTED RESEARCH AREA

David Cohen
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There is a tremendous lack of empirical data and documentation concerning curriculum development processes in general. In chemistry, literature on the subject is isolated and reports are unsystematic. Studies and literature concerning the effects of various types of curriculum development processes upon the nature of the resultant curriculum products could be most helpful in a number of ways. A new range of variables and a corresponding new field of terminology may need to be developed to support such studies.

In this connection, Walker (1969) has developed a model for the curriculum project development process, designated in terms of three "structural components":

> platform, comprising the shared vision of beliefs, assumptions, preferences and principles of the participants; aims, explanations, conceptions, exemplary products, procedures;
>
> task design, describing the jobs which participants set for themselves - present work, past accomplishments and failures, and future agenda; and including group tasks and their subdivision, the sequence and focus on topics;
>
> and
>
> deliberations - "The processes of give and take, challenge and justification, argument and advocacy employed by members as they work."

In the absence of existing data about the processes of curriculum development, Weiss and Edwards (1971) have suggested the construction of a new data bank, using the following steps:

1. Determine the decision-making components in curriculum development.
2. Determine the important dimensions on which decisions are made, through expert opinion, literature analyses, category systems, and project reports.

Relating these two proposals to chemistry curricula, one might ask what processes, for example, assist in streamlining the work of personnel involved in curriculum development, or in facilitating the work of teachers and professors who have the task of implementation? Those responsible for developing chemistry curricula could help substantially by keeping detailed, accurate records of their decision-making Processes:

Who was involved?

What influences were exerted by whom, and upon what issues?

What criteria (if any) were used in reaching decisions, and for which curriculum components?

Some other types of research questions include:

Does the prespecification of objectives make the processes of development and/or organization of learning experiences and/or of evaluation procedures more efficient or effective?

Does the use of curriculum *teams* of personnel promote the use of a wider range of valid decision criteria?

What ranges of differences occur internationally in the processes of chemistry curriculum development? What influences do these differences exert?

What key differences (if any) do and/or should characterize the processes of chemistry curriculum development at preuniversity and university levels?

Finally, in a recent review of research concerning the forces which influence curricula, McNeil (1969) commented that there was little evidence to suggest that knowledge about the process of curriculum development was significantly shaping school curricula. If that was true for curricula in general at secondary school level, it is even truer concerning *chemistry* curricula, and unfortunately a major understatement of the situation for university level chemistry curricula. Let us hope that we are about to witness a decade of change in our understanding and application of curriculum development *processes* paralleling in intensity the efforts of American secondary-school curriculum development projects!

CONTRIBUTED PAPERS I

Session G. Environmental Education

Presiding: William L. Sharp, University of Iowa, Iowa City, Iowa.

1. "Determination of the Factors Contributing to a Person's Values with Respect to Environmental Problems." Rodney L. Doran and Alfred A. Sarnowski, State University of New York at Buffalo, Buffalo, New York.

2. "The Design of a Modified Semantic Differential Instrument for Determination of Changes in Environmental Attitudes." William E. DeLucia and Donald C. Parker, East Syracuse-Minoa Central Schools, East Syracuse, New York.

3. "An Analysis of College Students' Interpretations of Some Possible Environmental Catastrophes." Frank Fazio, Indiana University of Pennsylvania, Indiana, Pennsylvania.

4. "The Development and Evaluation of an Elementary Environmental Attitudes Program." Sylvia G. Leith, University of Manitoba, Winnipeg, Canada and David P. Butts, University of Texas, Austin, Texas.

DETERMINATION OF THE FACTORS CONTRIBUTING TO A PERSON'S VALUES WITH RESPECT TO ENVIRONMENTAL PROBLEMS

Rodney L. Doran

and

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Buffalo, New York

The objective of the research described in this presentation was to provide some quantitative information to the general question - How and why do people view environmental problems as they do? Some of the host of factors related to this research question were such things as personal characteristics (age, sex, education, etc.), socio-economic variables (family income, parent's occupation, etc.), cognitive variables (knowledge of environmental relationships, comprehension of underlying scientific principles, understanding of the relationship between science and technology, etc.), and affective variables (general value preferences, anxiety, role perception, moral judgement, etc.).

The first stage of this research involved the development of instruments to validly and reliably measure the constructs mentioned above. Of primary concern was the development of devices to assess people's value preferences with [illegible] environmental problems. This variable was the criterion variable for subsequent analyses and evaluations.

The second portion of this research was to develop a model hypothesized to explain the relationships among the criterion variable and the several predictor variables. This model was based on past research efforts as well as on preliminary findings collected as part of this study.

Concern for our environment is at an all time high, the reasons being all too obvious. But research attempting to explain how and why people perceive environmental problems, their causes and solutions, has not been accomplished. This kind of information is needed so the political and educational leaders can develop and implement efficient and effective programs to deal with this highly divergent and difficult problem. Of particular concern in this study was the relation between science and technology and the environmental problems. It has been stated by some people that science and technology are to blame for many of the present environmental problems, while others look to science and technology for the correction and/or alleviation of these problems. The values one holds influence strongly what one perceives, accepts, and subsequently acts upon. This research was an attempt to determine what factors contribute to the development of one's value structure with respect to environmental problems.

THE DESIGN OF A MODIFIED SEMANTIC DIFFERENTIAL INSTRUMENT FOR DETERMINATION OF CHANGES IN ENVIRONMENTAL ATTITUDES

William E. DeLucia

and

Donald C. Parker
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East Syracuse, New York

The primary purpose of this study was to test the design of a semantic differential type instrument to determine student attitudes toward stimuli with ecological impact. A secondary purpose was to use the instrument to assess the changes in attitudes attributable to a short (10 week) unit in high school biology.

The construction of the instrument was done with 100 students who were previously exposed to a course in environmental science. From a total list of fifty adjective word pairs, this "ecologically experienced" group selected sixteen pairs as "best defining all aspects of the words: Envirommental Science." These bi-polar word pairs were constructed on a five unit scale and used by subjects to record responses to concept stimuli.

Colored slides were used as the concept stimuli in place of the written words which appeared in Osgood's basic design of the semantic differential. The authors selected 36 2" x 2" slides from a total of approximately 1600. The "ecological experienced" students selected seven slides as best representing the areas of (1) Man's Interaction With the Environment, (2) Technology and the Quality of Life and (3) Natural Ecological Balance. Reliability data were obtained by reselection procedures for adjective pairs and concept slides.

The test was administered in a manner similar to the ordinary semantic differential. Concept slides were presented singly allowing the subject time to react on a scale of 1 to 5 for each adjective pair. The analysis of the responses was by the principal components method using Varimax rotation. Factors with Eigenvalues greater than one were extracted and named in terms of the adjective pairs which contribute most. Component scores were then computed for each factor by standardizing the response and multiplying it by the Eigenweights. The component scores were then examined by analysis of covariance to determine changes related to the factor.

All the students enrolled in the New York State Regents Biology course (195) from a suburban school district took part in the research project. The total group was given the test and then the experimental group (N=68) was taught a two month unit dealing with environmental science. At the end of the unit all students took the semantic differential test again.

Analysis of the data isolated twenty-two factors related to the seven concept slides. Three of the factors indicated significant differences at the .01 level after two way analysis of covariance. All three of the significant factors were heavily weighted by adjective pairs related to interest and awareness.

AN ANALYSIS OF COLLEGE STUDENTS' INTERPRETATIONS OF SOME POSSIBLE ENVIRONMENTAL CATASTROPHES

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Indiana, Pennsylvania

Teaching science content that has real world relevancy is one objective that science educators are usually striving to attain. This exploratory investigation was an attempt to answer the following questions with respect to students' interpretations of real world problems.

1) Can college non-science majors interpret some predicted environmental catastrophes with respect to using past school science learnings?
2) What are the science misconceptions that non-science majors have with respect to interpreting these problems?
3) Can the students demonstrate and suggest the needed science background that could be used to provide the basis for a physical science course centered on the environmental problems?

Four possible environmental catastrophes as predicted by environmental writers were briefly described and presented to the students. The students were then instructed to respond to each of the four proposed catastrophes with respect to these three questions:

1) Please interpret in your own words the meaning of each predicted environmental catastrophe.
2) State any possible solutions that you think might be feasible in preventing the catastrophe.
3) If you feel that you need more background information or if you feel that you need to ask some questions about the predicted statement, what general or specific information would you like to know more about?

The science concepts that could be used to interpret the four proposed catastrophes were independently written by three competent judges. A composite summary was constructed and used by the researcher for analysis of the students' protocols.

The student sample used in this investigation consisted of 138 non-science majors enrolled in a physical science course. The data were collected at the beginning of the course with the hope that the results could help the instructor develop some background materials for the course. The written protocols were analyzed with respect to the above mentioned objectives. A science term analysis was also used to determine the frequency and occurrence of science terms used by the students. Since the nature of the study was exploratory and somewhat descriptive, the traditional statistical analyses could not be used.

A summary of the findings include the following:

1) Over 65 percent of the students were able to successfully interpret at least one or more of the four catastrophes.

2) Of the four predicted catastrophes, the one dealing with the Super-Sonic Transport and the possible depletion of the ozone layer was least understood and interpreted by the students.

3) Over 50 percent of the student solutions offered to the problems involved concerned automobiles, industry and government regulations.

4) Over 30 percent of the students suggested alternate substitutes for the polluting materials mentioned in the predicted catastrophes.

5) About 30 percent of the students expressed a need for more specific background related to the physical and chemical properties of substances and the mechanisms of the reactions involved.

6) About eight students' interpretations challenged the validity of the predicted catastrophes and presented reasons for the challenge.

7) Misconceptions generally centered around the reactions involved and the properties of such substances as carbon dioxide and mercury.

The results lend support to the notion that school science learnings can be used interpretively by non-science majors with respect to relevant environmental problems.

This type of analysis of the free written output of students has limitations with respect to making any clear-cut conclusions with statistical significance. However, this type of analysis is closer to the real world and the real behavior of people when they are responding to relevant problems. The findings in this specific study has led to establishing some background material for a physical science course centered on environmental problems. The findings have also suggested some areas of further research.

THE DEVELOPMENT AND EVALUATION OF AN ELEMENTARY ENVIRONMENTAL ATTITUDES PROGRAM

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and

David P. Butts
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Austin, Texas

The purpose of this study was to design and evaluate an environmental education program in which value clarifying strategies were used as agents for attitude change with the children taking the instruction. A second purpose of the study was to design a system of instruction to effectively develop student teachers to teach such a program.

The study was conducted using twenty-nine student teachers from a science methods class at the Faculty of Education, University of Manitoba. Fifteen students were arbitrarily assigned as experimental group student teachers and fourteen students were likewise designated as control group student teachers. The experimental group participated in instructional sessions designed to assist them to implement a specially designed environmental education program--Elementary Environmental Attitudes Program. In the classes of the student teachers of the experimental group, the children studied a unit in the Elementary Environmental Attitudes Program.

Each student teacher in both groups was given pre- and post-tests on the Environmental Semantic Differential and the Questionnaire on Environmental Problems. Each child in the classroom of both groups was given pre- and post-tests in the Environmental Semantic Differential and the Environmental Concern Inventory.

The results of this study indicated that both children and student teachers did show some attitude change with respect to the environment. Differences in the attitude change of the children seemed to vary based on classes the child was in, the topic the child studied, and the school the child attended. No relationship was found between the use of teaching strategies inherent in the system of instruction, and the attitude change of the children. Time was probably an important factor which controlled attitude change. More time than the three to four weeks used for the study is needed to effect attitude change of much extent.

CONTRIBUTED PAPERS I

Session H. Teacher Education

Presiding: Jerry Underfer, University of Toledo, Toledo, Ohio

1. "A Competency-Based Science Education Program for Third Through Sixth Grade Level Elementary Teachers Utilizing Modules with SCIS Environmental Education Materials in an Urban University School Cooperative Field Project: A Final Report." Jerrold William Maben, Herbert H. Lehman College, The City University of New York, Bronx, New York.

2. "The Effects of an ISCS Workshop on Attitude Changes Toward Science Teaching." Joy S. Lindbeck, The University of Akron, Akron, Ohio.

3. "A New Approach to Teacher Selection and Education for Inner-City Schools." George C. Turner, California State University, Fullerton, California.

4. "The Development and Evaluation of a Televised Science Inservice Program." Martha K. Piper, University of Houston, Houston, Texas and David P. Butts, The University of Texas, Austin, Texas.

A COMPETENCY-BASED SCIENCE EDUCATION PROGRAM FOR THIRD THROUGH SIXTH GRADE LEVEL ELEMENTARY TEACHERS UTILIZING MODULES WITH SCIS ENVIRONMENTAL EDUCATION MATERIALS IN AN URBAN UNIVERSITY SCHOOL COOPERATIVE FIELD PROJECT: A FINAL REPORT

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Herbert H. Lehman College
Bronx, New York

The project was developed as a feasibility study in Competency-Based Teacher Education Programs.

During the 1971-1972 academic year the Competency-Based Teacher Education Program (CBTEP) Science Committee of the City University of New York (CUNY) developed draft competency lists in three areas:

1) Scientific knowledge for elementary school teachers.
2) Processes in science for the elementary school teacher.
3) Teaching science to elementary school age children.

The Florida and AAAS guidelines and other CBTEP materials were major input sources. For 1972-1973 a goal was set to train selected classroom teachers at the third, fourth, fifth and sixth grade levels in specific competencies for teaching environmental education. A CBTEP subcommittee on environmental education was formed. Science Curriculum Improvement Study (SCIS) materials were selected to use in the competency-based training of the selected teachers at four centers within the City University of New York. Cooperating schools and teachers were selected by Lehman College in the Bronx, Richmond College in Staten Island, The City College in Upper Manhattan in Jamaica, Queens for the third, fourth, fifth and sixth grade levels, respectively.

After selection of the teachers for CBTEP training in environmental education competencies, a series of modular training sessions at the respective college centers and teachers' schools were conducted during the 1972-1973 school year. Materials related to the SCIS Life Science Units were utilized in each module session. The training was designed for competency development in three areas:

1) General Teacher Competencies in Environmental Education.
2) Specific Teacher Competencies in Environmental Education.
3) Specific Environmental Education Teaching Competencies.

The teachers were provided with the set of SCIS materials for use in their classrooms during the Spring Semester, 1973.

The focus of the project was on the competency training of teachers in environmental education. The Maben National Elementary Science Study Questionnaire was administered for background baseline data on the teachers. The teachers' classrooms were visited periodically during the conduct of the Life Science Units. Anecdotal records of classroom activity were written by the teacher. Samples of children's work in written and art form were collected. Results of the program were discussed during the training sessions. A modification of the Richmond Evaluation of Teacher Objectives for Environmental Unit instrument was administered to the teacher at the conclusion of the unit. Conclusions and recommendations were made concerning the effectiveness of the Competency-Based Teacher Education Field Project Training Modules.

THE EFFECTS OF AN ISCS WORKSHOP ON ATTITUDE CHANGES TOWARD SCIENCE TEACHING

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The primary purpose of this investigation was to determine attitude changes toward science teaching by teachers participating in an Intermediate Science Curriculum Study Workshop. It was hypothesized that teachers would change their attitude toward the meaning of science teaching with the acceptance of an individualized approach. A secondary purpose of the study was to determine if the teachers perceived the program structure as an effective method for orientation to the individualized approach of the Intermediate Science Curriculum Study.

The study involved 31 teachers enrolled in an ISCS workshop during July, 1973. The workshop program simulated ISCS classroom experience at the level of teacher assignment. Group programs focused on special problem areas identified with individualizing instruction--classroom organization and testing, the role of the student in creating a positive attitude, student evaluation, public relations, problems of ISCS substitute, etc. A one group pretest, posttest design was employed.

Pre- and post-data were collected with a modified semantic differential prepared by the investigator. Descriptive nouns and adjectives to increase the meaning of the variations in science teaching were used on twelve scales with the opposites separated by a seven point rating scale. The adjective or descriptive noun pairs were activity factors in describing the concept of science teaching.

A second instrument developed to measure the effectiveness of the workshop consisted of an evaluation of the attainment of the four objectives, a Likert rating scale for the fourteen activities of the workshop program, and open-ended questions for suggestions for future workshop programs. This second instrument was administered as a posttest only.

Analysis of the semantic differential data was conducted with a t-test for testing the significance of differences between related sample means. There was a significant change in attitude toward science teaching between the pretest mean and the posttest mean for the total (12) scale values at the .01 level of significance. On the individual scales there were differences in attitude toward science teaching between the pretest and posttest means for six scales which were significant at the .01 level and for four scales which were significant at the .05 level. For two scales, the differences in attitude toward science teaching between the pretest and posttest means were not significant.

The objectives of the workshop were attained by 90 percent or higher of the participants. The ratings on the fourteen activities of the program clustered around above average with the exception of three activities which clustered at average.

The semantic differential permits a rapid assessment of attitude toward science teaching. The attitude toward science teaching for an ISCS program is a critical factor. The workshop was effective in changing attitude in the direction of the individualized approach as indicated by the semantic differential. The mean scale results of the pretest permit a visual inspection of the teacher attitude position prior to the workshop and the mean scale results of the posttest provide a visual inspection of the extent of the change in their attitude caused by the workshop program. The semantic differential permits a more critical analysis of the effect of the workshop than the evaluation of the attainment of objectives or the rating of the workshop activities.

A NEW APPROACH TO TEACHER SELECTION AND EDUCATION FOR INNER-CITY SCHOOLS

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The Urban Science Intern Teaching Project is a specially designed program aimed at identifying, educating, and placing individuals who have an interest and aptitude for teaching science to the educationally-uninvolved student. The project was funded for one-half million dollars primarily by the National Science Foundation, with additional contributions by the California Department of Veterans Affairs, Los Angeles Unified School District, California State University, Los Angeles, and California State University, Fullerton.

The project came about through the realization that although there is a general surplus of teachers across the nation, there is still a need for teachers for the so-called inner-city schools, especially in the science/math areas. This condition continues primarily because teachers are seldom selected for, or specially educated for teaching in these schools, and those who enter them too often leave for the more familiar conditions of suburban districts.

The project developed a special screening process and educational program. The screening process involved selection teams composed of inner-city teachers, administrators, community-action representatives and science educators. A unique three-phase technique was used involving: (1) Preliminary Questionnaires and school visitations, (2) Simulation Tasks, and (3) a Control Task. Final selections were based on exhibited behavior characteristics reflecting strength and sensitivity.

One of the most important objectives of the project is to build a new model for teacher education. A major emphasis of the project was to shift the educational program from a college-centered to a school-centered activity. The effect is similar to the apprentice-journeyman relationship found in industry. This practical experience in the schools begins immediately when the student enters the program and continues throughout its entirety.

The first group of interns has completed the pilot program. From this group, seventy-five percent (75%) are now full-time teachers working in situations for which they were selected. An evaluation program has begun to determine appropriateness of the screening criteria and success of the teachers after their initial year.

THE DEVELOPMENT AND EVALUATION OF A TELEVISED SCIENCE INSERVICE PROGRAM

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and

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Austin, Texas

New elementary science curricula have developed over the past decade and called for complimentary changes in teaching methods. An essential ingredient for the successful implementation of these new curricula in the classrooms is teacher inservice education. Complicating this need for inservice education is the fact that teachers often have a predisposed negative attitude toward science and science teaching. Thus, the problem facing school systems in designing appropriate inservice or continuing education for teachers is twofold. First, there is a need to assist teachers in learning and practicing skills identified with the new science programs. Second, there is a need to interest teachers in science and science teaching to motivate them to teach science in their classrooms.

This study explored the following questions: Can a televised inservice program provide the means to adequately prepare teachers to teach science? If this is possible, will teachers be motivated to teach more science activities as indicated by their attitude change?

LIFT OFF!, a televised science inservice program lasting fifteen weeks, was developed to guide seventy-six elementary teachers in implementing Science - A Process Approach in their classrooms. Pre- and post-assessments were made of teacher attitudes and a criterion-referenced measure of science competency was obtained. Because of the large metropolitan setting for this study, teachers participated in the inservice activities either through cable television or video tape recorders. Fifty teachers participated in the program via cable television at a prearranged scheduled time and had no control over their inservice time. Twenty-six teachers participated in the program via video tape recorders which allowed them more flexibility in controlling their inservice time. The teachers using video tape recorders could start, stop, or repeat the telelessons as it fit their needs. Although the teachers achieved the desired criterion performance on the post-competency measure, the twenty-six teachers who had control over their inservice time scored higher as a group on the science competency measure when compared to the fifty teachers who had no control.

Based on an analysis of pre- and post-attitude scores the evidence indicated teachers' attitudes did change in a positive direction after being involved in the televised inservice programs. A weekly tally of activities taught showed a general increase over the weeks. It was concluded that positive attitude changes and increased science competency are associated with teachers' motivation to teach more science activities in their classrooms.

CONTRIBUTED SYMPOSIA I

Session A. Classroom Verbal Interaction Analysis

Presiding: Burton E. Voss, University of Michigan, Ann Arbor, Michigan.

1. "The Comparison of two Different Methods of Verbal Behavior Analysis." Alex Pogirski, Huron High School, Ann Arbor, Michigan.
2. "Neglected Aspects of Classroom Interaction: A Study of Pupil Participation in High School Biology Classes." Jal S. Parakh, Western Washington State College, Bellingham, Washington.
3. "Macroanalysis Patterns - A Step Toward Continuing the Development of Teaching Cycles and Toward Synthesizing Instructional Models." James R. Campbell, University of Pennsylvania, Philadelphia, Pennsylvania.
4. "An Examination of ISCS Teachers: To Determine the Degree of Influence that the Teacher's Personality has on Verbal Behavior Patterns and the Favorable or Unfavorable Teacher and Student Attitudes Toward the Course." Clyde Powell, Emerson Junior High School, Livonia, Michigan.

Discussant: "A Critique and Look Ahead." Ned Flanders, Far Western Regional Laboratory for Educational Research and Development, San Francisco, California.

THE COMPARISON OF TWO DIFFERENT METHODS OF VERBAL BEHAVIOR ANALYSIS

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The verbal interaction analysis accomplished by coding discrete verbal behaviors according to a specified time period, while looked upon favorably by many researchers, still appears to be out of the grasp of most teachers. Secondary school teachers, it would appear, prefer the use of checklists administered to students to gather data that would permit analysis of their classroom behavior.

In two separate studies, 1970-71 and 1972-73, conducted in Southeastern Michigan, the relationship between data gathered by use of interaction analysis techniques and data gathered by use of checklists, developed from the same interaction analysis model, were compared. In addition, the correlation between two different classes having the same teachers was accomplished. Ten different BSCS Green Version Biology Teachers, each with two class sections of approximately 25-30 students per section, comprised the sample.

Findings were:

1. Analysis of the checklist data reveals a very high correlation between the two different classes of each teacher on the students' perception of the teacher's verbal behavior.

2. The checklist data and the verbal interaction analysis appeared to conflict on the ranking of most teacher behavior. That is to say, the students appeared to rank the teachers in a more favorable manner than did the interaction analysis [directness to indirectness statements about the nature of science, etc.]

3. Correlations between the teacher's perception of his verbal behavior as recorded on the teacher's checklist and the data from the students' checklists were greater than the correlations between the data from the interaction analysis and the teacher's checklist or the data from the interaction analysis and the students' checklists.

4. It would appear from the data collected, teacher surveys, requests for assessment instruments, teachers prefer the use of checklists to the interaction analysis techniques.

NEGLECTED ASPECTS OF CLASSROOM INTERACTION:

A STUDY OF PUPIL PARTICIPATION IN HIGH SCHOOL BIOLOGY CLASSES

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Many studies of teacher-pupil interaction in science classes using the Flanders or some other category system have been reported within the past twenty years. In most of these category systems, including one previously developed by the author, the major emphasis has been placed on categorization of teacher behavior. The utterances of pupils are lumped into a few categories and reported as accounting for roughly 15 to 30 percent of the time spent in classroom discourse. It is not known whether all or a few pupils participated, or what qualitative and quantitative similarities and differences were present among those pupils who participated. Implicitly or explicitly the assumption is made that the teacher's behavior influences the pupils as a group and attempts are made to relate teacher behavior scores to various types of class mean scores.

Despite our pronouncements about the uniqueness of each learner, systematic quantitative descriptions of individual pupils engaged in classroom activity are particularly limited. Further, a striking gap exists in our knowledge of the complex relationships among teacher behaviors, pupil behaviors, pupil characteristics and pupil achievement.

Two "different" classes of each of eight high school biology teachers were observed for four consecutive days for a total of 64 lecture-discussion periods. Class sizes varied from 15 to 37 pupils per class. The live verbal behavior of each pupil was categorized into one of 36 categories of a system developed by the author and coded in the appropriate block of a seating chart. The entire classroom discourse was also recorded on audio-tape for additional analysis. In addition, data on pupil characteristics were obtained from school records and questionnaires were administered to pupils and teachers.

A few of the numerous findings are summarized below:

1. The 36 categories of the system were derived by combining four modes of pupil talk (Questions, Self-initiated Statements, Volunteering after General request, Replying to specific teacher request) with nine kinds of utterances (Defining, Fact-Stating, Explaining, Evaluating, Explicitly referring to Nature of Science, Indicating lack of knowledge, Suggesting Problem-Solving Procedures, Dealing with classroom routines and Utterances Unclassifiable in above). For example, the code QD_{40} entered on the seating chart would indicate that that pupil had asked a question regarding definition and that it was the fortieth pupil utterance during that class period.

2. In the average classroom of 24 students pupil talk accounted for about 20 percent of the time, there were about 45 pupil utterances per class period and four pupils accounted for about half of the pupil talk.

3. In the average classroom Volunteering and Replying after teacher's question accounted for 80 percent, Questioning and Self-initiated statements accounted for 20 percent of pupil utterances.

4. A preliminary search was made for relationships between and among four classes of variables, viz., teacher behaviors, pupil behaviors, pupil characteristics and pupil achievement. These findings are best viewed as leads to be followed up by further research, for example:

   a) Classroom behavior of pupils was significantly related to achievement as measured by the New York Regents Examination and teacher's final grade.

   b) Pupil characteristics such as intelligence, school and college aptitude, and attitudes were generally not significantly related to total pupil talk and certain categories of pupil talk.

   c) Sex and ability were significantly related to total pupil talk and certain categories of pupil talk.

Implications for future research and classroom teaching will be discussed at the meeting.

MACROANALYSIS PATTERNS - A STEP TOWARD CONTINUING THE DEVELOPMENT OF TEACHING CYCLES AND TOWARD SYNTHESIZING INSTRUCTIONAL MODELS

James R. Campbell
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Macroanalysis is the process of analyzing interactive dialogue in chains or sequences of coded behavior rather than in terms of the conventional matrices and ratios. This process was initially used with interactive data accumulated with the Flanders Interaction Analysis System (FIAC) and the Campbell-Rose Interaction System (CRIS). More recently it has been used with more diverse interactive systems.

Macroanalysis is a descriptive process which extracts all existing three-, four-, and five-tally chains directly from an observer's coded tallies. No matrices are used to derive the patterns, and consequently no inferences are involved. The process views teaching not from "microscopic" three or six second time sequences (one-two tallies), but from larger and larger groupings of data. The term "Macro" was coined to describe the increasing scope of the analysis. The focus of analysis is directed toward patterns of varying length.

To Bellack, Davitz, Kliebord and Hyman (1963) and others, many of these patterns could be called "teaching cycles." Bellack, et al., define their teaching cycles as linguistic events beginning with either structuring or soliciting moves and involving sequences of varying length. The macro-patterns involve a much greater variety of patterns than the 21 cycles outlined by Bellack. In fact, our own research studies have uncovered as many as 2500 to 3500 different three-tally patterns, 5800-8400 different four-tally patterns, and 9000-13,000 different five-tally patterns for various groups of junior and senior high school teachers. The macroanalysis output does provide the opportunity to reclassify many of these patterns within the "teaching cycle" framework. This new data pool should be expected to lead to progress in this line of research.

From our research, we have derived the following classes or groups of patterns:

1. T-S-T Patterns (Teacher Statement-Student Statement-Teacher Statement)
2. S-T-S Patterns (Student Statement-Teacher Statement-Student Statement)

3. Steady State Patterns (Patterns involving a repetition of the same category at least twice in succession).

4. Teacher Centered Patterns (Indirect and Direct Patterns)

5. Student Centered Patterns

6. Wait-time Patterns

7. Patterns which step up the cognitive level of the dialogue

8. Patterns which step down the cognitive level of the dialogue

9. Patterns which maintain the same cognitive level in teacher-student dialogue

The macro-patterns are also utilized in determining the exact number of tallies which occur in three, six, and nine second bursts. These calculations enable us to determine the percentage of tallies which occur in isolation, X-A-X, and also the number which occur in either of the sequences, X-A-A-X or X-A-A-A-X, where A represents one category and AA or AAA represents a repetitive sequence. The "X" represents any other category which occurs.

As an example of the kind of data that are produced by these calculations, we have determined that approximately fifty percent of cognitive memory questions occur within three seconds while convergent, divergent, and evaluative questions occur within much longer sequences. Similar conclusions can be made for student initiated dialogue.

All the analyses described above involve the isolation of individual patterns, however, the macroanalysis process does provide the data to combine these patterns into larger and more comprehensive instructional models or strategies. We have developed several of these models. They involve combinations of as many as forty different patterns which are included in one large scale cyclical model. Such models should give teachers a wide range of options and yet focus the interaction along predefined channels. Such models could also prove fruitful in isolating specific methodologies being employed by highly productive teachers or in isolating the type of interaction prescribed in more controlled studies.

AN EXAMINATION OF ISCS TEACHERS:

TO DETERMINE THE DEGREE OF INFLUENCE THAT THE TEACHER'S PERSONALITY HAS ON VERBAL BEHAVIOR PATTERNS AND THE FAVORABLE OR UNFAVORABLE TEACHER AND STUDENT ATTITUDES TOWARD THE COURSE

Clyde A. Powell
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The purpose of the study was to: (1) Administer the California Psychological Inventory (CPI) to a group of teachers in an ISCS institute who were beginning to teach the ISCS program, (2) to analyze the teacher behavior of these teachers by means of verbal interaction analysis, (3) to determine the relationship between teacher personality and verbal behavior in relation to the model teacher behaviors and to the favorable or unfavorable attitudes toward the ISCS course.

Sub-problems included:

1. To determine the degree to which ISCS teacher's personality characteristics correlate with teacher success as determined by the model ISCS teacher behaviors.

2. To determine the degree of correlation between ISCS personality characteristics and success as reflected by teacher attitudes.

3. To determine the degree of correlation between ISCS personality characteristics and success as reflected by students' attitudes.

4. To determine whether there was correlation between the model ISCS teacher behaviors and success as reflected by the attitude surveys.

5. To determine the effect of the institute on changing ISCS teacher behaviors towards those of the model ISCS teacher behaviors.

6. To determine effects of the interaction of teacher personality, background factors and the institute on teacher success as described by the model ISCS behaviors.

7. To determine its effects on the interaction of personality factors, background, institute on the success as reflected by the attitude surveys.

The study group consisted of nine members of an NSF inservice ISCS institute conducted on alternate Saturdays from September 1972 until April 1973 at Eastern Michigan University, Ypsilanti. Background data of the participants were collected from the NSF applications. All were teaching ISCS in their home schools and they all gave consent, both verbally and in writing, to participate in the study. Seven had no contact with ISCS prior to the institute, while two had had some experience. One of the two had had no formal contact with the philosophy or objectives of the program through workshops and one had had a six week summer class. All were teaching in schools within a sixty-five mile radius of Ann Arbor.

The teachers' verbal behavior was collected by remote audio recordings on tape to minimize the observer effect. Two class sessions per teacher were obtained in early fall and again in the late spring, after the institute was completed.

Other data were collected in this order: The CPI was given during the first institute session in September. The procedural questionnaire was given after the classes were begun in the fall of 1972. Then, in April 1973, the student and teacher attitude scales were given.

CONTRIBUTED SYMPOSIA I

Session B. Elementary-Secondary Curriculum Research and Development

Presiding: Bernard W. Benson, University of Tennessee, Chattanooga, Tennessee.

1. "Research Concerning Implementation of USMES." David H. Ost, California State College, Bakersfield, California.

2. "NSF: Pre-College Materials and Instruction Development (MID) Section Concerns." Daniel C. Yohe, National Science Foundation, Washington, D.C.

3. "Formative Evaluation of the Individualized Science Program." Leopold E. Klopfer, University of Pittsburgh, Pittsburgh, Pennsylvania.

4. "The BSCS Human Sciences Program." James T. Robinson, Biological Science Curriculum Study, Boulder, Colorado.

RESEARCH CONCERNING IMPLEMENTATION OF USMES

David H. Ost
California State College
Bakersfield, California

Frequently inferential statistics are used inappropriately. Problems related to external and internal validity are identified and analyzed. A brief review of research related to curriculum evaluation is presented. This review includes the monitoring and the use of descriptive statistics, assessment and use of descriptive statistics, and the implementation and use of inferential statistics.

This paper emphasizes a discussion of current research related to the development of the USMES Curriculum. Monitoring includes the materials development and implementation efforts. Likewise, assessment includes the same facets. The report includes the formative evaluation efforts completed to date.

NSF: PRE-COLLEGE MATERIALS AND INSTRUCTION DEVELOPMENT (MID) SECTION CONCERNS

Daniel C. Yohe
National Science Foundation
Washington, D.C.

The primary emphasis of NSF-supported pre-college curriculum development efforts is to improve the understanding and use of science and technology by the general populace. In addition, at the secondary level, we are concerned with helping to assure an appropriate supply and mix of the highest quality scientists and technicians. In keeping with the emphasis on science literacy at the pre-college level, new curriculum development efforts are likely to involve projects designed for a broad ability range of students, projects that are interdisciplinary in nature and projects that relate science and technology to environmental and societal problems.

The MID Section, under the category of instructional development, is also concerned with applying science and technology to improve the effectiveness of the educational process. Of special interest here are projects that involve application of innovative educational technologies and projects that involve experimentation with new structures and procedures in science education.

In FY 1974 the budgetary allocation for this Section's activities is less than $8 million, some of which is necessarily earmarked for continued support of on-going projects.

Other activities within the Foundation's Education Directorate are also concerned with certain aspects of pre-college education. An overview of these activities is available in publication E-74-1 from the National Science Foundation, Washington, D.C. 20550.

FORMATIVE EVALUATION OF THE INDIVIDUALIZED SCIENCE PROGRAM

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University of Pittsburgh
Pittsburgh, Pennsylvania

The formative evaluation of any instructional program is a complex process. When the program being evaluated is an individualized one whose development, field testing, and production are the responsibility of three different organizations, the complexity of the evaluation process is increased several fold. This paper will consider the formative evaluation process of Individualized Science (IS), an elementary school (K-8) science program being developed by the Learning Research and Development Center, field tested by Research for Better Schools, and published by Imperial International Learning Corporation. The program is unique in that it is the only individualized elementary school science program presently under development in the United States and it is one of the first, if not the first, federally funded curriculum development project in which a publisher is actively participating in the development process.

To make the discussion of the formative evaluation meaningful, the unique features of the IS program will be described first. Next, the activities in the development of the program and the four stages of its formative evaluation will be delineated. The stages in the formative evaluation of IS are designated by the letters A through D.

Stage A has two substages. During the first of these, answers are sought to questions relating to the IS program's conceptualization and planning. Written statements of the program's rationale, goals, objectives, and plans for development are examined by respected educators and subject matter experts. Their task is to compare the IS program's goals and rationale with accepted philosophical and psychological principles, societal goals of education, and the structure of the pertinent science disciplines.

The second substage of Stage A in formative evaluation is the critical review of the student instructional materials of the curriculum. The materials are evaluated on the basis of their consistency with generally accepted principles of pedagogy, with the stated philosophy of the curriculum, and with the accepted facts and ideas of science. In the development of IS, this phase of Stage A of formative evaluation generally occurs three times. The first occurrence is during the original creation of the instructional materials prior to prototype testing. The IS student instructional materials are critically reviewed again during the editing of the field testing version, and once again during the editing of the commercially published version.

During Stage B, students and teachers in prototype testing sites are observed as they interact with the IS instructional materials, as they interact with the classroom environment, and as they interact with each other. Observations of the interactions of students with instructional materials can provide data to answer questions about the material's short-term effects on student's behaviors relating to science content. The effectiveness of student instructional materials is evaluated on the basis of how well the observed student behaviors match those behaviors the materials purport to teach. The formative evaluation in Stage B is done by comparing the observed behaviors of the student and the teacher with the specified behavioral outcomes and procedures of the IS curriculum, as well as with generally acceptable classroom behavior. Information gained from the Stage B formative evaluation in the development of IS is useful for identifying weaknesses within learning activities and instructional materials. Revisions of prototype materials and procedures are made on the basis of this information. Once IS materials satisfactorily pass the Stage B evaluation, they are produced in a field testing version and the formative evaluation enters Stage C.

The Stage C formative evaluation of IS seeks answers to questions about the curriculum's intermediate-term effects on students' behaviors relating to science content, the nature of the learning environment and its effects on students' and teachers' behavior, and the ease with which the curriculum can be implemented and used by teachers in various types of non-experimental classrooms. Many of the questions addressed in the Stage C evaluation are the same as those addressed in the Stage B evaluation. There are two notable differences. The first is that during the Stage B evaluation, observations focus on the ease of use and effectiveness of IS learning activities in modifying the individual student's short-term behaviors related to science content, whereas the Stage C evaluation, while not neglecting the short-term behaviors, focuses more on the intermediate-term behaviors of students. The second difference is that the Stage B evaluation of IS is carried out in one or two prototype testing schools with small samples of students and often only a single teacher is involved; the Stage C evaluation on the other hand, is conducted in a larger number of field test schools and involves a larger number of teachers.

At the completion of the Stage C formative evaluation of IS, the effectiveness of the instructional materials, the ease of their implementation, and the effectiveness of the teacher preparation program have been evaluated with a limited sample of students, teachers, and classroom types. During the Stage D evaluation, more comprehensive answers to questions concerning the effectiveness of the teacher preparation program and the ease with which the IS program can be implemented are sought. Data collected from a larger, self-selected population, are evaluated on the same basis as in the Stage C evaluation. The marketability of the IS program is also evaluated during this stage by determining the rate at which the program is purchased by schools and whether or not schools continue to use IS after their first year's experience with it. The Stage D evaluation of IS is being carried out by Research for Better Schools (RBS) in approximately 100 schools in the RBS demonstration network. Data will be collected by RBS from IS teachers, children taking IS, and the parents of children taking IS. These data from children, teachers, and schools using IS will be evaluated by comparing them with data from control schools. The results of the Stage D evaluation will, of course, be of considerable academic interest and will hopefully be of use in preparing revisions of the IS program.

THE BSCS HUMAN SCIENCES PROGRAM

James T. Robinson
Biological Sciences Curriculum Study
Boulder, Colorado

The Human Sciences project, funded by the National Science Foundation, is creating a curriculum for early adolescents that is based on theoretical grounds that differ from those of other science curricula.

The theoretical base for the program was derived from consideration of the needs, interest, physical, psychological, and social characteristics of eleven- to thirteen-year-olds; from trends in American society and the world community; and from the natural and social science disciplines.

The alternative to subject matter organization being developed and tested by the project was derived from a large collection of student questions and concerns that the project staff developed from discussions with early adolescents, teachers, psychologists, and a review of the literature. These questions were reduced to a small, stable structure by devising the concept of generic questions. Generic questions were proposed as a device to represent and subsume the great majority of student questions and concerns in the development of the curriculum components. The four generic questions being tested during the development of modules for grades six, seven, and eight are:

1. Why do things change?
2. Why do living things act as they do?
3. What determines who gets what?
4. What is normal?

Major ideas from the natural, social and behavioral sciences, organized into three content themes, are serving as primary sources of content. The themes that restrict and guide the selection of various disciplinary elements are: continuity and change; competition, accomodation, and cooperation; and equality and inequality.

A module structure, breaking the curriculum into five- to seven-week segments, and composed of from twenty to thirty activities was devised as a structure that would provide the best "fit" with students. Each module is developed around a unifying theme, but students are provided with choices as to both the sequence in which they will engage in activities and the number they will do. Several levels of investigation and several different modes for learning are provided within each module. Modules are developed within the context of a single generic question. Five sixth-grade modules are being tested in the academic year 1973-74 in seven school systems. The seventh-grade modules will be tested in 1974-75 and the eighth grade in 1975-76.

CONTRIBUTED SYMPOSIA I

Session C. Three Approaches to Instrumentation and Data Gathering for Evaluation and Research in Science Education.

Presiding: Richard M. Bingman, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

1. "Descriptive and Judgemental Data--Some Lessons from a Formative Evaluation." Robert M. Bridgham, Stanford University, Stanford, California.
2. "Measuring Teacher Competence." James R. Okey and Donald W. Humphreys, Indiana University, Bloomington, Indiana.
3. "Analyzing Item Response Behavior as a Means to Estimate the Level of Cognitive Performance." John T. Wilson, University of Iowa, Iowa City, Iowa.

Discussant: Leopold E. Klopfer, University of Pittsburgh, Pittsburg, Pennsylvania.

THREE APPROACHES TO INSTRUMENTATION AND DATA GATHERING FOR EVALUATION AND RESEARCH IN SCIENCE EDUCATION

Science Educators today are faced with a wide range of evaluation and research tasks. Each task often requires multiple data gathering techniques in order to satisfy standards of adequacy, validity, and reliability. A major problem here also is the congruency of the instruments and techniques with the evaluation and research questions. This symposium focuses upon these diverse approaches to instrumentation and test construction relative to current evaluation and research problems in science education.

Approach 1:

Descriptive and Judgemental Data -- Some Lessons from a Formative Evaluation

Robert M. Bridgham
Stanford University
Stanford, California

In evaluating an inter-disciplinary collegiate program in Values, Technology, and Society an evolutionary approach to instrument construction has proved effective. This approach has enabled the evaluators to match the designer's articulateness concerning "what the program is about." Interviews, observations, and questionnaires have been used to gather both descriptive data and judgements, relative to the character of individual courses. Work on an instrument to assess outcome performances is now underway as the clarification of program goals has made it worthwhile. Sophisticated statistical manipulation has not been required. What has been crucial is the possibility of using data from a variety of sources to build a consistent picture of students' experience in each course that would be informative to program designers.

Approach 2:

Measuring Teacher Competence

James R. Okey

and

Donald W. Humphreys
Indiana University
Bloomington, Indiana

Field-based and competency-based teacher education programs have complicated the task of evaluating teachers. We need to measure a variety of teacher outcomes--what teachers know (cognitive), what they do (performance), and the results they produce (consequence);

each type of outcome may require different instruments or evaluation procedures.

Examples of cognitive, performance, and consequence teacher behaviors are given and procedures and instruments for measuring the achievement of each type of outcome are discussed. Attention is given to the evaluation of teachers in the various settings where they are trained--college classrooms, micro-teaching laboratories, and school classrooms.

Some of the many problems associated with measuring teacher competence are treated in the presentation. These include choice of appropriate designs for evaluation, creation of valid and reliable measures, and selection of criteria for measuring the effects of teaching.

Approach 3:

Analyzing Item Response Behavior as a Means to Estimate the Level of Cognitive Performance

John T. Wilson
University of Iowa
Iowa City, Iowa

Research indicates that items with greater dissimiliarity from the instructional material place an increased burden upon the processing performed by the subject. It seems to follow that items can be analyzed in terms of these processing differences as a means to estimate levels of cognitive performance. Here, five levels of verbal cognitive performance were selected and include (1) verbal information learning, (2) discrimination learning, (3) concept learning, (4) principle learning, and (5) problem solving. Melton's multiprocess model of learning, which examines a performance of a task in terms of performance variables, processing requirements, analyzing items and assessing performance within each of the five levels selected is discussed.

CONTRIBUTED SYMPOSIA I

Session D. Research in Teacher Education

Presiding: Ronald D. Townsend, Evanston Township High School, Evanston, Illinois.

1. "Formative Evaluation of a Competency Based Teacher Education Program." Robert K. James, Kansas State University, Manhattan, Kansas.
2. "Continuing Clinical Experiences as a Part of a Four Year Teacher Education Program." Vincent N. Lunetta, University of Iowa, Iowa City, Iowa.
3. "Preservice Teacher Education in Secondary Science and Mathematics at The Ohio State University." William R. Brown, Old Dominion University, Norfolk, Virginia.
4. "Changes in Self-Concept of In-Service Teachers: A Preliminary View." James P. Hale, Glencoe Public Schools, Glencoe, Illinois.
5. "Development and Use of a Science Teaching Competencies Checklist and Teaching Philosophy Inventory with Pre-Service and In-Service Science Teachers." Melton E. Golmon, University of Maryland, College Park, Maryland.

FORMATIVE EVALUATION OF A COMPETENCY BASED TEACHER EDUCATION PROGRAM

Robert K. James
Kansas State University
Manhattan, Kansas

In a recent publication Bloom and others stress the need for evaluation in both the "teaching and learning process . . . while they are still fluid and susceptible to modification."[1] Formative evaluation focuses on the need for remediation so that subsequent instruction and study can be more pertinent and beneficial. It is particularly suited to evaluation of smaller units of instruction such as the modules in competency based instruction. The application of this concept to a competency based teacher education program at Kansas State University has been made during the past four semesters.

The success of instructional programs and materials in achieving the objectives of the project is the central focus of the formative evaluation effort. Input is provided through feedback from students, their classroom supervisors and project staff. Mechanisms for feedback include checklists, group rap sessions, module evaluations and one-on-one diagnosis and remediation. The project staff synthesizes these inputs into an overall instructional improvement effort.

A model for providing product assessment through on-the-job evaluation by district supervisors in school districts where teachers are employed is presented.

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[1] Bloom, Benjamin, J. Thomas Hastings and George Mades, Handbook on Formative and Summative Evaluation of Student Learning, New York: McGraw Hill Book Company, 1971, p. 20.

CONTINUING CLINICAL EXPERIENCES AS A PART OF A FOUR YEAR TEACHER EDUCATION PROGRAM

Vincent N. Lunetta
University of Iowa
Iowa City, Iowa

Over the past few years, programs for the preparation of science teachers at the University of Iowa have been in the process of gradual evolution. As the program has evolved the professional education phase has become more thoroughly integrated with the students' total program than it was previously. In the current program, seminars and clinical experiences introduce science-oriented students to issues and strategies in science education early in their college years.

Prior to the UPSTEP program at Iowa preservice science teachers were provided no opportunity to work in the public schools in extended experiences before student teaching at the conclusion of their undergraduate program. In the first UPSTEP program model, sophomore students worked for one semester in an "early exploratory experience" with a cooperating teacher in the public schools. Close communication has been maintained between the UPSTEP staff, the students, and the cooperating teachers. Questionnaires completed by the students and the teachers have shown positive responses to this phase of the UPSTEP program. In fact, feedback from both teachers and students has caused the staff to expand this part of the UPSTEP program.

In response to comments from students and from cooperating teachers, the UPSTEP staff in the early Fall of 1973 began to make clinical experiences a more central part of the evolving UPSTEP program. Meetings have been held with teachers, students, and school officials to develop a bank of appropriate tasks which UPSTEP students would perform over a period of several semesters. The paper will present an overview of the evolving program and research effort.

PRESERVICE TEACHER EDUCATION IN SECONDARY SCIENCE AND MATHEMATICS AT THE OHIO STATE UNIVERSITY

William R. Brown
Old Dominion University
Norfolk, Virginia

A series of six investigations were conducted at The Ohio State University between 1968-1972. This series dealt with a two-year sequence of field-based experiences in the training of preservice secondary science or mathematics teachers.

Two studies were oriented toward the science preservice program. Instruments used were the Science Classroom Activity Checklist: Teachers's Perceptions, the Science Classroom Activity Checklist: Student's Perceptions, Skeel's Cultural Attitude Inventory, the Checklist for Assessment of Science Teachers: Supervisor's Perceptions, the Checklist for Assessment of Science Teachers: Pupil's Perceptions, and several questionnaires. Both studies dealt with the senior year sequence which included student teaching. The experimental program (project) was run concurrently with a more traditional non field-based program (non-project). The experimental program emphasized participation in both urban and suburban classrooms (S_1) immediately preceding student teaching (S_2). Methods of analysis included correlations, multiple regression, and analysis of variance. Among the conclusions were (1) project participants had significantly greater knowledge of culturally deprived students at the end of S_1 than did non-project participants, (2) the major influence on the activities used by student teachers for science instruction during S_2 was the cooperating teacher, (3) S_1 teachers changed their views significantly about the types of science classroom activities which should be used in urban or suburban classrooms at the completion of S_1. This group retained their gains on these measures as assessed at the completion of S_2, and (4) cooperating teachers who perceived their facilities as being adequate and who used course content improvement project materials were rated high by their classroom students on the SCACL:SP or on the CAST:PP.

A first year follow-up of teachers who had participated in either the project or the non-project sequence was conducted and reported by two investigators. Ohio State graduates were compared to non-Ohio State graduates who taught science in the same building. Among the conclusions were (1) project teachers did not change significantly in their views of the types of activities that should be used for inquiry-oriented instruction during their first year of teaching, (2) project teachers used more inquiry-oriented teaching methods than non-project teachers as measured by the SCACL:SP, (3) the OSU non-project teachers appeared to hold a more restrictive and less open-ended view of the types of laboratory activities which should be used for science instruction at the completion of the school year, and (4) the OSU graduates placed a higher value on the importance of using innovative teaching strategies to maintain or obtain a quality science program than did the non-OSU teacher graduates.

The two year sequence in mathematics education was researched in 1970-71. Eighth graders were tutored by university juniors as part of the junior year project. Instruments administered were the *Teaching Situation Reaction Test*, Bill's *Index of Adjustment and Values*, the *Mathematics Teaching Inventory*, Massie's *Contemporary Mathematics Test for Teachers*, the *Comprehensive Test of Basic Skills* (arithmetic section), an *Attitude Inventory*, and several questionnaires. Among the conclusions were: (1) the project members revealed a significant increase in the TSRT for the J_2 quarter and the entire project; the participants' measure of self-concept on the IAV increased steadily over the two quarters but did not reach significance and (2) the tutored group of eighth graders scored significantly higher than the non-tutored group on the Math vs. Non-Math and Facilitating Anxiety subscales of the *Attitude Inventory*. The tutored group had a greater increase in computation scores, but the difference between the experimental and control groups was not significant.

The *Mathematics Teaching Inventory: Teacher Perceptions*, Skeel's *Cultural Attitude Inventory*, the *Teaching Situation Reaction Test*, the *Mathematics Teaching Inventory: Student Perceptions*, questionnaires, and logs were used to assess the effects of the senior year sequence. Among the conclusions were (1) project pre-service teachers held significantly more positive views of what should occur in the mathematics classroom at the end of S_1 than at the beginning. The changes in reactions to teaching situations and cultural compatability were also more positive but not significant and (2) the most dramatic result of the study was that during the student teaching quarter the preservice teachers (both project and non-project) exhibited significant losses on each of the criterion variables.

The findings of these studies have given the faculty data upon which to make decisions for program evolution.

CHANGES IN SELF-CONCEPT OF IN-SERVICE TEACHERS:

A PRELIMINARY VIEW

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During one of the sessions of the in-service class that I teach through National College of Education, a teacher came up to me and said, "You make me do things in my teaching that I wouldn't have done before taking this course!" This statement brought a very interesting and relevant question to mind. Does the particular approach (i.e. the S.S.L.S. Program) that I utilize in my in-service classes bring about significant positive changes in the teachers' self-image and attitudes towards science? This paper is a result of a preliminary analysis of this question.

The sample consisted of fifteen in-service teachers enrolled in the National College of Education course entitled "New Developments on Elementary School Science." The approach utilized by the instructor was that of the *Student-structured Learning in Science* (S.S.L.S.) program by Matthews, Phillips and Good. The research instruments employed were the *Q-sort of Single Adjectives* by Donald Humphreys and the *S.S.L.S. Attitude Inventory* by Matthews, Phillips and Good. Both instruments are still in development and, therefore, limit the generalizability of this study.

The instruments were administered to each student on the second and eleventh (last) meetings of the in-service course. The t-test for related measures and Spearman's rank-order correlation were used to statistically analyze the data.

The results of the data analysis indicate that there was a significant change in the in-service teachers' self-image and their S.S.L.S. Attitude Inventory mean scores. Low positive and low negative correlation were indicated when comparing the in-service teachers pre and post-test Q-sort scores (+.06), pre-test Q-sort and S.S.L.S. Attitude Inventory scores (+.39), post-test Q-sort and S.S.L.S. Attitude Inventory scores (-.10), and pre and post-test Attitude Inventory scores (+.37).

The tentative conclusion of this study is that the use of the S.S.L.S. approach in in-service education has some positive effect on the teachers' self-image and attitudes towards science. Data obtained from the administration of the *Q-sort of Single Adjectives* to approximately thirty Chicago area elementary school teachers are being analyzed. The purpose of this data collection was to gain basic data related to the reliability of this instrument as a tool for measurement of teachers' self-image.

DEVELOPMENT AND USE OF A SCIENCE TEACHING COMPETENCIES CHECKLIST AND TEACHING PHILOSOPHY INVENTORY WITH PRE-SERVICE AND IN-SERVICE SCIENCE TEACHERS

Melton E. Golmon
University of Maryland
College Park, Maryland

The purpose of this study was to develop a science teaching competencies checklist and a science teaching philosophy inventory for use in the assessment of pre-service and in-service science teachers.

The Science Teaching Competencies Checklist was developed with the assistance of science supervisors attending academic year institutes and of science teachers attending in-service and summer institutes at the University of Maryland. The final form includes 200 tasks deemed useful for science teachers in general. There are four possible responses for each task depending on how well a teacher can perform it. The Science Teaching Philosophy Inventory was developed to reflect teaching philosophies inherent in the nationally prominent curriculum projects. The final form consists of twenty statements designed with a Likert scale format.

These two instruments were administered to science education majors on a pretest and posttest basis at the beginning and completion of the science methods course which is offered concurrently with student teaching. An analysis of variance was used to test the hypothesis that there would be no difference in science teaching philosophy as a result of experiencing the science methods course and student teaching. Pretest and posttest results of the Science Teaching Competencies Checklist were analyzed on a part by part and item by item basis.

These two instruments were also administered to in-service teachers with three or more years of teaching experience on a one time basis. A comparison was then made between posttest results of pre-service science teachers and results of in-service science teachers.

The results of such analyses indicated:

1. The teaching philosophy of pre-service science teachers does change as a result of having experienced a science methods course and student teaching as measured by the Science Teaching Philosophy Inventory.

2. There is a large increase in the number of competency tasks a pre-service teacher can perform as a result of having experienced a science methods course and student teaching as measured by the Science Teaching Competencies Checklist.

3. Science teaching philosophy posttest results of pre-service teachers are similar to results of experienced in-service teachers.

4. Science teaching competencies posttest results of pre-service teachers differ in a number of ways from those of the experienced in-service teachers.

CONTRIBUTED SYMPOSIA I

Session E. New Research Models for Science Education

Presiding: Robert B. Collagan, Morgan State, Baltimore, Maryland.

1. "Philosophical Analysis Applied to Problems of Science Education: A Promising Alternative Approach to Research." Douglas A. Roberts and Thomas L. Russell, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada.

2. "Implications from Thomas Kuhn's The Structure of Scientific Revolutions for Research in Science Education: The Need for Paradigms." Barbara Bowen, IACC Day Care Center, Ithaca, New York.

3. "Path Analysis as a Tool for Science Education Research." Lee T. Bryant, State University College at Geneseo, Geneseo, New York.

4. "A Path Analysis Model for Physics Enrollment." Rodney L. Doran, State University of New York at Buffalo, Buffalo, New York.

PHILOSOPHICAL ANALYSIS APPLIED TO PROBLEMS OF SCIENCE EDUCATION:

A PROMISING ALTERNATIVE APPROACH TO RESEARCH

Douglas A. Roberts

and

Thomas L. Russell
The Ontario Institute for Studies in Education
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This paper explores and demonstrates the usefulness of a relatively under-developed but highly promising approach to research in science education. Based on techniques of philosophical analysis, this approach requires the rigorous development of theoretical frameworks, or "sets of eyes," from systematic philosophical work on issues specific to science, and on the meaning of educational concepts such as teaching, learning, knowledge, etc. Once a theoretical framework is developed, a "clue structure" can be derived from it and subsequently can be used to identify and characterize aspects of science teaching materials, classroom discourse, etc., in terms which are species-specific to science education. Thus, for example, classroom observation schemes already developed by this approach have their roots in philosophy of science, epistemology, and philosophical analysis of teaching and learning, rather than borrowing their key concepts from, say, social psychology, as the Flanders system does.

This paper is not yet another plea for greater awareness among science educators of the philosophy of science and the philosophy of education. Rather, it is an argument in favor of expanding the number of recognized research paradigms in science education to include at least one alternative which differs radically from the hypothetico-deductive approach we have borrowed from the natural sciences and social sciences. While not denying the value of sound empirical research, this paper calls attention to the value of the fresh and rigorous vantage point which philosophical analysis provides for the conceptualization of problems in science education.

The first part of the paper is a synopsis of general features of the techniques employed when philosophical analysis is used as a basis for science education research. Several pioneering studies in the area are examined, in this overview.

The second part of the paper is a presentation of research in progress, as a specific illustration. Stephen Toulmin's "argument pattern" (from his The Uses of Argument, 1958) is the analytical tool used to determine whether excerpts of science classroom dialogue are suggesting to pupils a "rational" or "traditional" attitude toward authority in science (R. S. Peters, Authority, Responsibility, and Education, 1959).

IMPLICATIONS FROM THOMAS KUHN'S THE STRUCTURE OF SCIENTIFIC REVOLUTIONS FOR RESEARCH IN SCIENCE EDUCATION: THE NEED FOR PARADIGMS

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To date, research in science education has been formulated on the basis of a methodological rather than a conceptual view of science and scientific research. Research with this orientation has yielded little progress in the conceptualization of knowledge in the field. It is the thesis of this paper that formulating research on the basis of a Kuhnian view of science, transforming it from a methodology-guided to a paradigm-guided enterprise, would promote such conceptualization and the continued growth and articulation of knowledge in the field of science education. In short, research with a conceptual orientation and basis would permit knowledge in the field of science education to progress in the manner characteristic of a science.

The scientific enterprise as described by Kuhn is not primarily methodological, but conceptual. Methodology is derivative, not generative. Experiments are designed and data are collected and interpreted under the aegis of the current paradigm in a given field. As more and more data are collected and interpreted in light of a given paradigm, the paradigm becomes more highly differentiated and the picture it affords of a certain slice of the world becomes more detailed. Neither the individual scientist nor the scientific community carries out research in a conceptual vacuum. Nor is a methodology the basis, but rather is derived within the context of a well-defined conceptual framework, i.e., paradigm.

The problem of formulating paradigm-guided research in science education is not that of creating or generating a paradigm *de novo*, but of identifying one or several extant models or theories of learning as a possible paradigm to guide research. Such a theoretical framework must be capable of being articulated and differentiated as research data are gathered and interpreted in its light. It must be neither too narrow nor all-inclusive, so that soluble research problems can be generated from it.

An example of the kind of conceptual framework which would not be suitable as a paradigm is Skinner's model of operant conditioning. This model is plausible as a description of only a certain narrow range of learning behaviors. It does not begin to be able to explain the kind of conceptualization and hierarchical ordering of information and knowledge which typifies learning of science. A model which offers more promise is Ausubel's formulation of the nature of meaningful learning and cognitive differentiation.

PATH ANALYSIS AS A TOOL FOR SCIENCE EDUCATION RESEARCH

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This study was undertaken to investigate the use of path analysis as a technique for gaining better understanding of some science education problems. Path analysis is a technique for developing and evaluating models for situations involving causal assumptions. The technique has been used extensively in social science research particularly in the area of sociological research. As science educators often investigate problems similar to those found in sociology, it was felt that the technique might be a useful research tool for some problems in science education.

The technique of path analysis was used to develop a model for some variables thought to be related to percentage enrollment in physics (PEP) for secondary schools. This required postulating, solving, and validating a causal model having PEP as the criterion variable.

A path analysis model is a network of variables connected by directed arrows which represent the postulated causal relationships among the variables. The variables are usually arranged in a left to right order going from the general to the more specific, and finally to a single criterion variable. When the model is solved using a given data set, the magnitudes associated with each arrow are obtained. These magnitudes indicate the strength of each relationship and are called the path coefficients. Finally, path analysis provides several methods for testing the validity of the model. These methods serve as means for rejecting inadequate models.

The data for this study were collected and supplied by the New York State Education Department and consisted of information related to the school characteristics, physics teachers, and physics classes for 807 secondary public schools. The data were originally collected for administrative purposes but have been made available for educational research.

This investigation demonstrated that path analysis can be an extremely valuable technique for reaching a better understanding of science education problems of this type. The path analysis model not only indicated how the variables related to the criterion variable, but how they related to each other. As all the relationships are graphically represented in the model, they are much easier to interpret than a table or matrix of numbers. The directed arrows in the model make the causal assumptions explicit such that the results can only be viewed in the context of the assumptions.

For many science education studies, causal assumptions are made even if they are not explicitedly stated. Causal modeling through the technique of path analysis makes these assumptions explicit and provides an easily interpreted display of the interrelationships among a set of variables.

This study has demonstrated that the technique of path analysis can be used to postulate, test, and interpret causal relationships. The models developed can then be used as a focal point for further research and in the context of decision models to suggest ways in which science education can be improved.

A PATH ANALYSIS MODEL FOR PHYSICS ENROLLMENT

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This study was undertaken to develop a path analysis model for percentage enrollments in physics (PEP) for secondary schools. Previous studies have identified many variables that appear to be related not only to physics enrollments, but also to each other. This suggests that a unified model would be useful for better understanding the relationships and interrelationships between these variables and PEP. A path model for PEP would help not only to bring together the results of previous studies, but also serve as a focal point for future investigations of physics enrollments.

The model for PEP was developed using the technique of path analysis which requires that a model be postulated, solved, and tested. As many models will be found by the testing procedures to be inadequate, this process must be continually repeated until a model is found which meets the test criteria. Initially variables were available that represented characteristics of schools, physics students, physics teachers, and physics programs. Using PEP as the criterion variable, the initial model was postulated using the results of previous studies to suggest the selection and placement of variables in the path model. As the initial model failed to meet the test criteria, the model was repeatedly modified until ultimately a model was found that successfully met these criteria. Finally, a drawing was made showing the structure of the PEP model and the path coefficients associated with each path in the model.

The data for this study were collected and supplied by the New York State Education Department and consisted of information about 807 secondary public schools and their associated 1088 physics teachers and 2547 physics classes for the 1970-71 school year. The data were originally collected for administrative purposes, but have been made available for educational research. Because the data were collected in machine readable form and required of all secondary public schools and their physics teachers, the information should have extremely high reliability.

The path model developed for PEP contains these variables: per cent of students from welfare families, amount spent per student for instruction, total school enrollment, number of students per teacher, dropout rate, per cent of students going on to a four year college, per cent of physics students enrolled in a traditional physics course, and per cent of physics students taking physics before the twelfth grade. Of these, the college variable had the largest direct effect on PEP while the welfare variable had the smallest direct effect.

As with all causal models, great care must be taken in interpreting the results. While this model is based on data from 807 secondary schools and has met several test criteria, the possibility still exists that one or more of the causal assumptions may be invalid. However, the model appears to be useful in better understanding how some factors influence physics enrollments.

Physics enrollments continue to remain low in the secondary schools. If an effort is to be made to increase these enrollments, a better understanding will be needed of the factors which influence physics enrollments. These factors represent a complex network of interrelated variables which can not be easily understood by a set of bivariate relationships. The path model developed in the study gives a better understanding of the physics enrollment problem. Hopefully, this can ultimately suggest ways in which physics enrollments can be increased.

RESEARCH REPORTS

Session A. Review of Teacher Behavior Research

Presiding: Eugene Lee, Emory University, Atlanta, Georgia.

Presentor: Patricia E. Blosser, The Ohio State University, Columbus, Ohio.

REVIEW OF RESEARCH RELATED TO TEACHER BEHAVIOR IN SCIENCE EDUCATION WITH ANALYSES OF RELATED FIELDS

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This review of research is a joint effort of Drs. Balzer, Blosser, and Evans and is a cooperative project of the ERIC Clearinghouse for Science, Mathematics, and Environmental Education and the Association for the Education of Teachers in Science. The literature reviewed covers the period of 1960 - 1970 although some documents of historical interest are also included, despite publication dates which precede the ten year period of the review.

The review is divided into three parts. In part one, Balzer reviewed research studies which had as the primary focus that of instrument development for use in observational studies of science classrooms. In part two, Evans reviewed studies of teacher behavior in science classrooms. He also included studies in areas other than science, however, in order to contrast and compare techniques. In part three, Blosser reviewed studies done in areas other than science and attempted to relate findings from areas such as social studies, elementary education, etc. to those in science education.

Each of the three reviewers has a slightly different style, both in reviewing and in writing. No attempt was made to edit each section so that a common style and format would result. Each of the three sections of the monograph could stand alone but, in combination, these sections provide a comprehensive picture of teacher behavior research in science education and a representative picture of teacher behavior research in other areas. The production of dissertation studies concentrating on teacher behavior has been such, within the last seven years of the 1960-1970 period of the review, that it was not possible to complete an exhaustive review in all fields other than science education.

Each section of the monograph contains a list of conclusions based on the studies reviewed for that specific section as well as a list of recommendations. Some recommendations are common to both science education and other fields. Some recommendations are unique and reflect the philosophy and interests of the particular reviewer making the recommendations.

In addition, each section contains a bibliography divided into studies described within the body of the review and additional studies. Many of the documents cited are available through the Educational Resources Information system and have been previously cited in Research in Education or in Current Index to Journals in Education. Other sources are Dissertation Abstracts and papers presented at annual meetings of various professional organizations.

RESEARCH REPORTS

Session B. Review of Research in Science Education - 1972

Presiding: Paul Westmeyer, Florida State University,
Tallahassee, Florida.

Presentor: Joseph D. Novak, Cornell University, Ithaca, New York.

REVIEW OF RESEARCH IN SCIENCE EDUCATION - 1972

Joseph D. Novak
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Ithaca, New York

This is a report of research studies in science education for 1972. Abstracts of unpublished research and references to published research reports were provided through ERIC. The ERIC documents and appropriate journals were reviewed to identify all research studies in science education reported in 1972. Studies were read and reviewed according to a variety of categories such as instruction, learning theory, and Piaget related studies. The review is critical in nature and points out learning theoretical deficiencies as well as methodological deficiencies in many of the research studies. The report at the NARST meeting includes a discussion of the rationale for classifying the studies and for the criticisms expressed.

RESEARCH REPORTS

Session C. Forty Years of Research in Science Education

Presiding: Ronald D. Anderson, University of Colorado,
Boulder, Colorado.

Presentor: Willard J. Jacobson, Teachers College, Columbia
University, New York, New York.

FORTY YEARS OF RESEARCH IN SCIENCE EDUCATION

Willard J. Jacobson
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This is a comprehensive review of about 40 years of research in science education. The "Reviews" are reported in six volumes and are now available to the science education community and other practitioners. The first three volumes are the "Curtis Digests" which have long been out-of-print. The succeeding volumes by Robert W. Boenig, J. Nathan Swift, and Elizabeth Phelan Lawlor review research through 1957.

Objectives of this review are:

1. To provide a functional guide to the research literature for use by the science education researchers.
2. To provide a concise review of science education research for use by practitioners and policy planners.

The general methodology involved careful searches of the science education literature, the preparation of annotated bibliographies, the selection of the most valuable studies by juries of experts, and the preparation of the digests of research studies and the final annotated bibliographies. In two of the analyses a citation method was also used in the selection of the most valuable studies.

Data sources were journals that report science education research, the "Review of Educational Research," bibliographies and footnotes in books, survey studies and yearbooks. The "Curtis Digests" contain digests of some unpublished studies. The later "Reviews" have been limited to published studies.

Six volumes of digests of science education research studies, annotated bibliographies, supplementary bibliographies, and some evaluations and discussions of trends by the authors resulted. These reviews of research in science education are a guide to the research literature in science education through 1957. A summary of science education research for this period is now available to teachers, supervisors and policy planners as they deal with the practical problems of improving science education.

RESEARCH REPORTS

Session D. Research in Environmental Education

Presiding: Marvin Druger, Syracuse University, Syracuse, New York.

Presentors: Felicia E. West, American Association for Advancement of Science, Washington, D.C.

Dean Bennett, Maine Environmental Education Project, Yarmouth, Maine.

Barbara Clark, Minnesota Environmental Sciences Foundation, Inc., Minneapolis, Minnesota.

Kay Davis, Fernbank Science Center, Atlanta, Georgia.

Donald Cook, Environmental Protection Agency, Washington, D.C.

RESEARCH IN ENVIRONMENTAL EDUCATION

Felicia E. West
American Association for Advancement of Science
Washington, D.C.

Education is an ever-changing process. Children, students, and adults provide new challenges for educators as the culture which produces them and the environment that tolerates them change. These challenges are and must be met by constant alteration or revision of the approaches, methods, curricula, and teaching aids in an effort to meet needs of learners as determined by an ever-changing society. Too often these alterations and revisions occur without a firm foundation based on educational research; too often educational research that is accomplished is not readily available to all who participate in these alterations.

This series of research reports will present in summary form the research programs and activities associated with the projects of the members of the Consortium of Regional Environmental Education Councils. This Consortium is composed of the following members: Minnesota Environmental Sciences Foundation, Inc.; New Jersey State Council for Environmental Education; Maine Environmental Education Project; Cooperative Science Education Center, Inc. of Oak Ridge, Tennessee; Fernbank Science Center of Atlanta; Quality Environmental Council of Nebraska and Western Iowa; Cleveland Museum of Natural History; Environmental Education Center at Portland, Oregon; and incoming member, the North Carolina Division of Curriculum Development.

Three representatives from the Consortium present summaries of the research activities carried out by the various members of the Consortium. The fourth panel member presents a possible direction for environmental education in the future. A summary statement in terms of a direction for future research in environmental education is also presented.

CENTER CAUCUSES

Session A. Indiana University

Presiding: Hans O. Andersen, Indiana University, Bloomington, Indiana. "Research in Science Teacher Preparation in Indiana University: Experimenting with University-School Cooperation, Field Based Instruction, Competency Based Instruction, and Process Product Research."

Session B. The University of Georgia

Presiding: John W. Shrum, The University of Georgia, Athens, Georgia. "Involvement with Modular, Self-Paced, Competency-Based Instruction in Both Methods Courses and Science Courses for Elementary Teachers."

Session C. University of Northern Colorado

Presiding: Robert Sund, University of Northern Colorado, Greeley, Colorado.

"Research Relative to Piget's Theory: Creativity; and Self-Evaluation Inventories as a Means of Assessing Student Achievement."

CENTER CAUCUSES

Session D. The Pennsylvania State University

Presiding: H. Seymour Fowler and Paul E. Bell, The Pennsylvania State University, University Park, Pennsylvania.
"Testing of Theories of Learning" e.g., Snyder Prototheory; Comparison of Alternative Strategies for Instruction.

Session E. Michigan State University

Presiding: Edward L. Smith, Michigan State University, East Lansing, Michigan.
"The Science and Mathematics Teaching Center at Michigan State University; Conceptual Systems and Inquiry Strategies Implementation and Dissemination Impact."

Session F. University of Texas at Austin

Presiding: David P. Butts, University of Texas at Austin, Austin, Texas.
"Curriculum Development and Evaluation, Teacher Education."

Session G. University of Maryland

Presiding: J. David Lockard, University of Maryland, College Park, Maryland.
"Teacher Education, Assessment and Evaluation Studies, Programmed Materials, Curriculum Evaluation."

CENTER CAUCUSES

Session H. University of Iowa

Presiding: George W. Cossman, University of Iowa, Iowa City, Iowa. "Piagetian Studies, Kinetic Analysis of Verbal Discourse, Teacher Education, Classroom Behaviors, CAI and Other Programmed Materials, Attitudinal Studies, Implications of History and Philosophy of Science."

Session I. The Ohio State University

Presiding: Robert W. Howe, The Ohio State University, Columbus, Ohio. "A Review of Research Studies at The Ohio State University: Teacher Behavior, National Surveys, Teacher Education, Concept Development."

DISCUSSION PAPERS I

Session A. "The Proper Experimental Unit: Comparative Analyses of Empirical Data."

Presiding: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania.

Authors: J. Dudley Herron, Thomas Luce, and Van E. Neie, Purdue University, West Lafayette, Indiana.

Session B. "The Cooperative Teacher Education Project: Pre-Service Outcomes."

Presiding: Roger Olstad, University of Washington, Seattle, Washington.

Author: Orrin E. Gould,University of Illinois, Urbana, Illinois.

Session C. "An Evaluation of a Performance-Objective-Based High School Chemistry Curriculum."

Presiding: J. David Lockard, University of Maryland, College Park, Maryland.

Author: Louis A. Gatta, Deerfield High School, Deerfield, Illinois.

DISCUSSION PAPERS I

Session D. "On Using Qualitative Data to Evaluate Two Chemistry Courses."

Presiding: Paul Westmeyer, Florida State University, Tallahassee, Florida.

Author: Glen S. Aikenhead, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Session E. "Formal Operational Thought and the High School Science Curriculum."

Presiding: Tom Grgurich, Cherry Hill High School, Cherry Hill, New Jersey.

Author: Ann C. Howe, Syracuse University, Syracuse, New York.

THE PROPER EXPERIMENTAL UNIT:

COMPARATIVE ANALYSES OF EMPIRICAL DATA

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Thomas Luce
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In 1967 James Raths wrote an article on "The Appropriate Experimental Unit" for Educational Leadership. In that article he argued that, in most educational studies, the appropriate experimental unit in the analysis of data is the class section rather than the individual student. Most researchers use the individual as the experimental unit.* In 1968 H. J. Fletcher wrote an article in the Psychological Bulletin pointing out "Possible Interpretative Problems in Analyses Using Group Means as the Experimental Unit."

Since Fletcher's discussion was based on fictitious data, the validity of his conclusions would be strengthened with real data. With this in mind, the faculty and students in the Science Education Seminar designed and conducted an experiment to determine the effect of two variables on achievement in a beginning college chemistry course. The two variables were (a) emphasis placed on a list of behavioral objectives for each unit of work and (b) the presence or absence of a requirement that students score at least 80 percent on each weekly quiz. Although the results of the study itself are of some interest, the primary focus is on the analysis of the data. The results have been subjected to a number of different analyses as outlined here:

1. Using total points in the course as the criterion variable, a 2x2 factorial ANOVA was performed to determine whether, (a) emphasis on the lists of objectives or, (b) being forced to score 80 percent on weekly tests or, (c) some interaction of these two variables, had any effect on student performance. This analysis was done using the individual student as the experimental unit and repeated using the class as the experimental unit.

2. The above analyses were repeated with the exception that SAT-V, SAT-M, or both scores were used as covariates in an ANCOVA.

3. Analyses indicated in 2 were repeated except that SAT scores were used as a factor for stratification of the sample into high, average, and low ability groups rather than using the SAT scores for a covariate.

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*To use the class as the experimental unit results in the loss of several degrees of freedom, thereby reducing the chance of detecting experimental differences.

4. Analyses similar to each of the above were performed using "number of quiz scores over 80 percent" as the criterion variable in place of total points in the course.

The purpose of this paper is to present the results of the various "equivalent" analyses -- equivalent in the sense that each analysis is an attempt to answer the same research question. The discussion centers on the differences in interpretations that can be made on the basis of one analysis as compared to the alternative analysis.

THE COOPERATIVE TEACHER EDUCATION PROJECT:

PRESERVICE OUTCOMES

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The Cooperative Teacher Education Project (CTEP) is unique in the manner and degree to which the responsibility and setting for preservice teacher education is shared by public school and university faculty. With the shift in both setting and responsibility, one must ask if differences accrue to the product. CTEP research has addressed such questions in terms of self-concept, commitment, job-taking, "valuing" and attainment of selected objectives for teacher education, and pupil and administrator appraisal of teachers' in-class behaviors.

CTEP began in 1971 as an informal cooperative between the University of Illinois (Urbana campus) and High School District 214 (about 20,000 students in the northwest suburbs of Chicago), but has expanded to include Northern Illinois University and several elementary districts that "feed" to District 214. Over 450 teachers-in-training, divided among the several major teaching fields, have participated and have been recommended for certification.

While the CTEP concept includes in-service teacher education, the preservice program has been the most visible part of the project. Each institution commits staff to the cooperative for both the design and implementation of programs. The tasks of instruction and supervision of candidates fall mainly to public school faculty. University faculty have more direct involvement with in-service activities of the districts. Candidates spend a full semester in the program and receive nearly all of the credit in professional education required for certification in Illinois. Their work, reaching into several schools at all levels--elementary, junior high school and high school, is guided by a set of program "components" that carry such names as mini-teaching, human relations, subject seminar, institutional study, elementary teaching, observation/election, and extended teaching. Stress is placed upon the need for candidates to define and develop personal strengths and interests, and considerable opportunity is afforded them to elect facilitating sites and cooperating teachers for the extended teaching component.

CTEP evaluation addresses both preservice and in-service goals, as well as organizational questions. The preservice studies, focusing on several different groups of CTEP candidates and students in conventional programs over four semesters, have been carried out by several investigators using methods that include questionnaires, observation, structured interviews, and specialized and conventional measuring instruments.

A notable difference between CTEP candidates and traditionally trained teachers is the pattern for job placement following graduation. For science and mathematics in 1972, the proportion of CTEP graduates taking teaching positions following graduation was over twice that for the conventionally trained and was also greater than in the days of the teacher shortage. Differences in self-concept between CTEP and conventional students are suggested both by statistical analysis of data obtained by such instruments as the Occupational Characteristics Inventory and the Personality Orientation Inventory, and by inference from the fact that 1972 CTEP graduates either took jobs in highly competitive schools or did not enter teaching at all. Conventionally trained students spread themselves in teaching jobs over a wide range of schools and communities, but generally in geographic areas that are less competitive for job-getting than the pattern for CTEP alumni.

Regarding the "valuing" of selected goals for teacher education, CTEP and conventional students are similar in their assessment, both groups perceiving their personal attainment to be at higher levels than might be the actual case. The sources that students perceive as having been of benefit for attaining these goals differ, conventional students attributing most of their attainment to student teaching to the exclusion of nearly all formal course work. CTEP candidates give greatest over-all value to the extended component, but see such other components as mini-teaching and involvement in the elementary schools as contributing to goal attainment out of proportion to their rather low cost in time and energy.

Regarding beliefs and attitudes toward teaching, Minnesota Teacher Attitude Inventory data show that altruism and idealism seem to dissipate over the CTEP experiences. A specially devised instrument, Beliefs Regarding Education, also indicates that CTEP candidates moderate their points of view away from the ideal end of the scale. As a seemingly related item, the Illinois Teacher Evaluation Questionnaire, administered to about 8,000 pupils by CTEP candidates and conventional student teachers, indicates that pupils perceive CTEP candidates differently than conventionally trained student teachers and more like experienced teachers. An inference is that CTEP seems to have particular effectiveness for shaping (or selecting) beginning teachers for conventional (realistic) roles in conventional (realistic) schools.

From structured interviews, CTEP candidates and alumni are generally lavish in their praise of the program, but see room for improvement in particular components and are inclined to attribute any personal feelings of anxiety or self-doubt to failure by their mentors or designers of the program. Teachers and administrators in the CTEP schools vary in attitude toward the CTEP concept, negative feelings being the strongest among people who have had the least opportunity for input. Employers generally give CTEP alumni high marks in enthusiasm, openness to new and novel teaching gambits, idealism, autonomy, and tolerance of individual differences in students. On the debit side, CTEP candidates are occasionally judged short in discipline or classroom control.

AN EVALUATION OF A PERFORMANCE-OBJECTIVE-BASED HIGH SCHOOL CHEMISTRY CURRICULUM

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The purpose of this study was to evaluate a performance-objective-based high school chemistry program. The evaluation was based on cognitive achievement and attitude toward chemistry developed in this program.

The students enrolled in chemistry at Deerfield High School, District 113, were randomly assigned to two treatment groups. The teachers in the first treatment group taught directly from the objectives stated for this chemistry program. Their students were given a copy of the objectives for each instructional unit and the activities and experiments were all geared for the accomplishments of the stated objectives. The teachers in the second group agreed on the validity of the objectives, but their students were not given a copy of the objectives and they taught in the same manner as they had taught in previous years.

The instruments selected to compare the two treatment groups on achievement were developed by the chemistry teachers taking part in this study. The instruments were all validated and reliability studies conducted to justify their use in this study.

The instrument selected to compare differences in attitudes of the students in the two treatment groups was The Attitude Toward Any School District.

The data were collected during the first semester of the 1972-73 academic year. A groups-within-treatments design was used to analyze the data for all achievement measures used in this study. The data collected for the attitude measure were also analyzed using a groups-within-treatments design. The results of the analysis indicated:

1. Students in the objective-based chemistry curriculum showed significantly greater achievement than students in the regular chemistry curriculum.
2. Students in the objective-based chemistry program showed significantly better attitudes than students in the regular chemistry program.

ON USING QUALITATIVE DATA TO EVALUATE TWO CHEMISTRY COURSES

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Quantitative data have specific limitations as far as giving feedback to teachers and curriculum developers is concerned. A complementary or alternative form of evaluative information could enhance the quality of the evaluation process. This information emerges from asking such qualitative questions as: What ideas have students learned? What misconceptions did they acquire? What misunderstandings have they still retained?

The specific problem of this study was to answer these questions for the Saskatchewan Chemistry Curriculum Committee by generating the appropriate evaluative data. The CHEM Study and Modern Chemistry (2nd edition) programs were evaluated with respect to chemistry students' knowledge about the scientific enterprise.

The subjects participating in the study were the chemistry students (N = 734) of 28 teachers randomly selected from a population of 353 Saskatchewan chemistry teachers (1972-73). Three instruments were administered in a random fashion: (1) a modification of Kimball's Nature of Science Scale, (2) Welch's Science Process Inventory, and (3) Korth's Test on the Social Aspects of Science.

Student response to these three instruments was analyzed in two ways. The McNemar chi square statistic yielded a list of items which experienced statistically significant change in student response between the pretest and posttest. The content of these items reflected the impact of the chemistry course on students' knowledge about the scientific enterprise. A second item analysis simply determined the percentage of correct response (as well as the percentage of students who did not understand the item), thereby leading to a list of strengths and weaknesses of Saskatchewan students.

The investigation revealed that in both chemistry programs there was a balance between a gain in understanding and an acquisition of misconceptions. The meager increase in understanding for the CHEM Study group tended to concern some social aspects of science, while the Modern Chemistry group slightly increased their understanding of some processes of science.

Misunderstandings arose concerning, in part: (1) the role of imagination and intuition in doing science, (2) the scope of a scientist's investigation into natural phenomena, (3) the aims of science, (4) the nature of quantitative data, (5) the use of the simplicity value in scientific thinking, (6) the role of serendipity, (7) the modification of theories in light of new evidence, and (8) the meaning of induction and deduction.

Also identified were specific ideas which indicated strengths and weaknesses in students' understanding about science and scientists. Some of these ideas are described here. Over half of the students erroneously thought that: (1) scientific classification schemes are inherent in nature, (2) scientific laws are permanent truths, (3) the point of experiments is to prove the laws of nature, (4) there is such a thing as "The Scientific Method," (5) money automatically buys scientific results.

Over half of the students did not know that: (1) there are limitations to the use of scientific inquiry, (2) scientific models are similes or metaphors and do not duplicate reality, and (3) scientific knowledge is tentative. Over half the students did not understand the meaning of induction, deduction, hypothesis, and theory. Over half the students also confused the aims of science with the aims of technology. These results were similar to those of recent American surveys.

The increased specificity in the qualitative results over solely quantitative data improves the feedback for the formative evaluation process. The information concerning the impact of the CHEM Study and Modern Chemistry courses on students' knowledge about the scientific enterprise is useful empirical feedback to any chemistry educator in many provinces and states.

Only when science educators have a list of specific misconceptions generally held by high school students, can curricula be developed or modified to overcome deficits in student understanding. The data from this investigation greatly contribute to the validity of such a list.

FORMAL OPERATIONAL THOUGHT AND THE HIGH SCHOOL SCIENCE CURRICULUM

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The ability to solve certain types of problems and perform certain cognitive tasks marks the transition from childhood to adolescence in Piagetian Theory. The theory proposes that adolescents enter into the Stage of Formal Operational Thought at which time the 16 binary propositions of formal logic become available to them and are used in problem solving and task performance. If the existence of a Stage of Formal Operational Thought could be supported and the age of acquisition confirmed, there would be obvious implications for both curriculum and teaching methods in secondary school.

The present study was undertaken to determine whether there is a body of research evidence to support the theory of a Stage of Formal Operational Thought, whether there is agreement as to the Age of Acquisition of Formal Operational Thought and the effect of schooling on the acquisition of the ability to perform formal operational tasks.

The research on this stage of development is meager in comparison to the amount of work which has been done on the earlier developmental stages. Much of the work has been done by developmental psychologists, is not reported in educational research or opinion journals and is, thus, not easily available to teachers and others in science education. For this study an extensive review of the literature, including many journals outside the field of education, has been carried out.

Results of this study include:

1. There is very little evidence for a Unitary Stage of Formal Operational Thought. Piaget himself has recently published a modification of his earlier view and Lunzer, whose early research seemed to support the theory, has recently reinterpreted his results.

2. Since there is so little evidence for a Unitary Stage of Formal Operational Thought, it is not possible to define an age of acquisition of Formal Operational Thought. There is a large body of evidence which shows that there is great variation in the age at which subjects are able to perform specific formal operational tasks.

3. There is evidence to show that schooling has an effect on the age at which subjects become able to perform formal operational tasks. This is in contrast to the findings in relation to concrete operational thought, which is acquired regardless of school experience.

4. Specific science curricula do not seem to effect change in performance on formal operational tasks.

5. Other findings relating to differences between sexes, correlation of performance on different formal operational tasks, and performance on related tasks are not clear cut.

The results of the review of the literature suggest that the idea of one stage of Formal Operational Thought may not be useful in the attempt to understand adolescent thought and to design high school science curricula. There are indications that many adolescents and adults who are capable of formal operational thought use concrete methods of problem solving whenever possible and that concrete methods may lead to greater retention. The entire area of adolescent intellectual functioning has been almost completely ignored in the design of high school science curricula which is, perhaps, one cause of the failure of the new curricula to have the far reaching results which were expected. The relation of reading comprehension to intellectual development is an area which has not been studied extensively but which might yield important information.

CONTRIBUTED PAPERS II

Session A. Curriculum Development

Presiding: Michael L. Agin, Michigan Technological University, Houghton, Michigan.

1. "Reading Comprehension and the Measure of Science Achievement Using the 1968-1969 ISCS Test and the Revised ISCS Test." David W. Allen, Philadelphia Board of Education, Philadelphia, Pennsylvania.
2. "Factors Concomitant with Approach and Avoidance Behavior with Respect to Enrollment in High School Physics Courses." J. P. Laurence, Detroit Public Schools, Detroit, Michigan.
3. "An Analysis of Reinforcement and Feedback Within an Auto-Tutorial Plant Taxonomy Module." John D. Hunt, University of Northern Colorado, Greeley, Colorado.
4. "A Study of Predictors of Success in Ninth-Grade Science and Mathematics and its Relationship to a Racial Desegregation Project." Violet R. Strahler, Dayton Public Schools, Dayton, Ohio.

READING COMPREHENSION AND THE MEASURE OF SCIENCE ACHIEVEMENT

USING THE 1968-1969 ISCS TEST AND THE REVISED ISCS TEST

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The 1968-1969 Intermediate Science Curriculum Study (ISCS) test on Volume I of Probing the Natural World was thought to be difficult for handicapped readers (H) (i.e., class mean reading level on the Iowa Test two years below the readability level of the ISCS test) to comprehend each item with ease within the time limit of the test. This study investigates whether the H group had a problem reading the ISCS test and presents an eclectic method for adapting the ISCS test so that it might be more understandable for handicapped readers.

The study was conducted in the Philadelphia Public Schools during the 1969-1970 school year and involved testing 35 seventh grade ISCS classes of 13 teachers in 7 schools.

A pilot study was run to see if a revision of the ISCS test was needed. Classes were categorized into two groups: (1) H classes which had mean reading levels two years below the ISCS test (i.e., readability -- 7th grade 3rd month, Dale Chall Readability Formula) and (2) NH classes which had means above fifth grade fourth month on the 1970 ITBS reading comprehension subtest. Two H and 4 NH classes were identified in the pilot study and 15 H classes and 14 NH classes, in the major study.

Pilot study findings indicated readability of the test was a problem (e.g., too near chance level in March) and that orally reading the items as presently written did not increase H pupil understanding of questions, so a Revised ISCS test was designed.

The Revised ISCS test used 38 of the 44 items from the original test. The rewording of items and addition of 11 illustrations, plus the oral-demonstration presentation of half the items were techniques used to design a parallel but less reading dependent test. Pilot study pupils scored an average of one point higher on the oral subtest than the silent subtest. The major study procedures included a replication of the pilot study.

In addition, achievement over the 1969-1970 school year was examined using a repeated measures design. The 1968-1969 ISCS test was administered in September and March and the Revised ISCS test was administered in June. Since the two forms of the test covered the same content, they were assumed to be parallel. A comparison of achievement over the year was made between H and NH classes to see if reading was an important factor.

Item analysis data were analyzed to see what changes in the psychometrics of the two instruments occurred as a result of revision.

The Hotelling t test was used to see if the Revised ISCS test had a reduced correlation with reading as compared with the 1968-1969 ISCS test.

Findings include the following:

1. The H group mean of 11.3 ($n = 188$, $SD = 3.86$) was within chance range of original ISCS test. The H group mean of 13.6 ($N = 188$, $SD = 3.81$) was significantly above the chance range on the Revised ISCS test.

2. ANOVA results indicated 15 H classes made significant gains from September to June. However, post hoc analysis indicated gains from September to March on the original ISCS test were not significant.

3. MANOVA analysis of 15 H and 13 NH classes indicated a significant difference existed between the two groups' science achievement. (March, 16.4 vs. 11.3 and June, 19.4 vs. 13.6).

4. A t test of the difference between means on oral and silent subtests of the Revised ISCS test suggested a treatment effect since the oral subtest mean was higher (i.e., $p < .05$).

5. Decrease in item difficulties of certain items was the major change in psychometrics. Ten items had significant changes in proportion of H pupils answering an item correctly from the March to June testing. Seven items appeared to decrease in difficulty because of revision and 3 as a result of recent learning.

6. Hotelling t test results indicate that the Revised ISCS test was significantly more correlated with the 1969 ITBS reading comprehension subtest than the 1968-1969 ISCS test. This resulted in part because of a nonsignificant correlation between the original ISCS test and the reading comprehension subtest.

The findings indicate that a written science test can be revised to insure that the lack of reading ability does not block the measure of science items on the Revised ISCS test. The revision of the test, plus the oral-demonstration presentation, indicated to pupils that the test administrator was interested in them doing their best on the science test. More humane techniques, with multimedia redundancy, should be used when administering tests to handicapped readers if valid measures of learning are desired.

FACTORS CONCOMITANT WITH APPROACH AND AVOIDANCE BEHAVIOR WITH RESPECT TO ENROLLMENT IN HIGH SCHOOL PHYSICS COURSES

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This study was designed to examine possible explanations for the recent decline in high school physics enrollments. Five hypotheses were tested:

1. There is no significant difference between the physics approach or avoidance behavior of students who remembered past science courses as being student-centered and those who did not.

2. There is no significant difference between the approach and avoidance behavior of those students who remembered their science teachers as warm personalities and those who did not.

3. Fear of failure does not influence a student's approach or avoidance behavior.

4. The reading level of the pre-physics science textbooks used by selected school districts are not beyond the reading level that could be expected of the students for whom they were adopted.

5. There are no advanced content items in the pre-physics science textbooks of the selected school districts.

The sample was drawn from six Detroit, Michigan, metropolitan high schools: two Detroit public, two Detroit suburban public, and two parochial--one Detroit and one suburban. One school district was chosen because of its high physics enrollment compared to the other schools. To test hypotheses one, two and three, a special instrument, the Science Educational Experience Perception Inventory, was designed. The instrument was tested for validity by a panel of three judges. Its reliability was tested by the split half correlation method. Textbook readability was examined by the Dale-Chall readability scale utilizing the Goltz reading equivalence scale for the Dale-Chall formula, and a survey of content in advance of the grades for which they were intended.

Student-centered and teacher warmth scores were compared by analysis of variance techniques. The determination of significance was done by the Fisher F ratio at the 0.01 level. The testing of hypothesis three was done by cross tabulations with the chi square at the 0.05 level.

No significant difference was found in the case of hypothesis one. Neither physics approach nor physics avoidance students remembered their science courses as having been student-centered. Hypotheses two and three were both found significant at the 0.01 level. Males showed a greater tendency to approach physics than females; females showed a slightly, but not statistically significant, greater variance for teacher warmth than males. It was also found that the non-promotion percentage in science was ten times as great for the low physics enrollment district than for the high enrollment district. The tenth grade biology text of the low enrollment group produced the largest yield of advanced content items.

The outcomes of this study suggest that changes are needed to improve physics elections. The course could be rendered less difficult. Physics teachers could examine their mathematical approach for coincidence with that of the student's mathematics training. Textbooks could be selected more realistically; perhaps more global and less modular curriculum planning could be used to this end. It also suggested that modern curricula might indicate a readjustment of the sequence in which science is taught. Finally curricula in high failure systems should be carefully scrutinized with the aim of reducing the fear of science in general and physics in particular.

AN ANALYSIS OF REINFORCEMENT AND FEEDBACK WITHIN AN AUTO-TUTORIAL PLANT TAXONOMY MODULE

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The purpose of this study was to compare the performance of students receiving immediate reinforcement and feedback within an auto-tutorial system to the performance of students in the same system but not receiving immediate reinforcement and feedback.

Fourteen teachers of biology in grades nine and ten of the Waco Independent School District, Waco, Texas, were asked to participate in this study. Two teachers from this group were randomly selected for active participation in the study. From two lists of the 150 students in the classes of the selected teachers, two groups of twenty-four students were randomly chosen. The first twenty-four comprised the control group; the second twenty-four, the experimental. I.Q.'s from the California Test of Mental Maturity were obtained from the school records.

The initial step in developing the learning module was to define, in writing, the behavioral objectives for the concepts to be developed. Originally, seventy-five 35-mm Ektachrome slides, eight worksheets comprising a workbook, ten living specimens, and a pretest and posttest were submitted on a pilot basis to thirty tenth grade biology students. Subsequently, an analysis was made of student responses to workbook questions of the amount of time involved in completing various phases of the program, and of the responses within the evaluation instrument. The original script and test were revised and shortened before use in the final investigation. A review of related literature showed that few studies using the auto-tutorial method of individualized instruction have been conducted at the high school level and that no investigations dealt specifically with the variables within this model. Therefore, the data collected on these forty-eight students were analyzed primarily with reference to the effect of the use of reinforcement and feedback within each system. Two multiple linear regression equations were used. The first analyzed the contribution of two variables, time used to complete workbooks and group membership, to predict pretest and posttest scores. The second analyzed these variables, along with I.Q., to determine their contribution to gain in scores.

This study indicates that the time spent in completing the test had no significant effect on pretest or posttest achievement in either group studied. A full linear regression equation containing variables of group membership and time to complete the workbook was compared to a restricted linear regression equation omitting time. The degrees of freedom used in this comparison produced an F-value insignificant at the .05 level. No significant relationship was found between the time spent in completing the workbook and the gains in achievement made by the groups.

Three restricted multiple linear regression models were employed to test the contribution of student I.Q. to the gain in score. The F-values obtained from these comparisons were significant at the .01 and .05 levels.

Two multiple linear regression models were used to analyze whether the program of immediate reinforcement and feedback, as used in the experimental group, had any effect on the gain in scores in this experiment. A significant difference existed between the gains made by the two groups at the .01 level.

A STUDY OF PREDICTORS OF SUCCESS IN NINTH-GRADE SCIENCE AND MATHEMATICS AND ITS RELATIONSHIP TO A RACIAL DESEGREGATION PROJECT

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The purpose of the investigation was to examine the relationship of certain information available on permanent record cards of a selected group of pupils and the success of these pupils in science and mathematics courses they studied in the ninth grade.

The research was limited to that of 324 pupils who attended three different high schools during ninth grade in 1966-67 in Dayton, Ohio. The common predictive factors studied were language and nonlanguage mental maturity test scores, achievement test scores in reading, arithmetic and language, and teachers' marks in eighth-grade science, English and mathematics. The ninth-grade factors with which the eighth-grade factors were correlated were teachers' marks in ninth-grade science and mathematics. Subjects were sorted in various ways to form seventeen different groups. Single and multiple correlation coefficients were determined and analyzed using F-ratios. Significance of correlations was determined by using tables, and significant differences between correlations were identified with Fisher's Z-statistic. The sign test was used to test the difference between two correlated sets of scores.

The results showed that all factors considered accounted for some variability and could have been predictors of success of ninth-grade science and mathematics. English eight grade point average (GPA) scored highest in correlation with science but not significantly higher than any other factors except nonlanguage mental maturity. Science eight GPA and mathematics eight GPA also were significantly better predictors than nonlanguage mental maturity. Multiple correlations gave a maximum coefficient of 0.602 with science nine GPA and of 0.539 with mathematics nine GPA.

The major significant difference between data for boys and for girls in science was the amount of variability accounted for in the two groups: 44 percent in boys and only 26 percent in girls.

Only 36 percent of the variability of individuals in science and 29 percent in mathematics were accounted for by the factors used. Introductory Physical Science student data gave higher correlations with mathematics and lower with language achievement. While 38 percent of the variability of all individuals in algebra was accounted for, only 16 percent was accounted for in general mathematics. Mathematical achievement correlations for both science nine GPA and mathematics nine GPA were significantly higher in the predominantly black school than in the predominantly white.

CONTRIBUTED PAPERS II

Session B. Academic Achievement

Presiding: Fred DeLuca, Iowa State University, Ames, Iowa.

1. "Predictors of Achievement in an Audio-Tutorial Physical Science Course for College Non-Science Majors." John W. Butzow, University of Maine, Orono, Maine and Roland R. Pare, Hunterdon Central High School, Flemington, New Jersey.
2. "Pupil/Science Teacher Interpersonal Compatibility and Science Attitudes." Robert A. Bargo, Syracuse University, Syracuse, New York.
3. "Performance Versus Verbal Ability: Implication for Curriculum Building?" Glenn H. Crumb, Western Kentucky University, Bowling Green, Kentucky.
4. "Student Misconceptions in Chemical Equilibrium as Related to Cognitive Level and Achievement." Alan E. Wheeler and Heidi Kass, The University of Alberta, Edmonton, Alberta, Canada.

PREDICTORS OF ACHIEVEMENT IN AN AUDIO-TUTORIAL PHYSICAL SCIENCE COURSE FOR COLLEGE NON-SCIENCE MAJORS

John W. Butzow
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Orono, Maine

and

Roland R. Pare
Hunterdon Central High School
Flemington, New Jersey

The need for studying the variables involved in audio-tutorial courses have been cited by many authors. A review of the literature suggests that the majority of the studies on the topic are comparison studies of conventional and audio-tutorial methods. There is enough research to indicate that no one method is consistently better than another in conveying knowledge.

There is a strong need, therefore, to learn more about those variables that are related to achievement in an audio-tutorial (A-T) course. The course used in this study was a one-semester course for non-science majors, notably those preparing to teach at the elementary school level.

The course consisted of 16 units of instruction available to the students as options. No attendance was specifically required. Student achievement was measured by contract. The contract levels indicated the number of units successfully completed as: A = 5 units, B = 4, C = 3. Grades below C were given by default. This study considered data on the 90 students enrolled in Studies in the Physical Sciences in Fall, 1972.

The major hypothesis tested in this study was:

It is not possible to predict the number of units a student will complete in a semester with knowledge of the following factors:

1. Attitude towards the method of instruction and the course itself. The attitude assessment made at the start of the semester is used.
2. The independence of student work habits as measured by the Study Preference Record.
3. Scholastic Aptitude Test scores: both verbal and mathematical.
4. The student's cummulative grade point average as it appears on the student's records.
5. Critical thinking ability as measured by the Watson-Glaser Critical Thinking Appraisal.

6. The number of science and/or mathematics courses a student has completed in the past. This was determined by counting the number of semesters a student has completed in science and/or mathematics in both college and high school.
7. Student's class membership: how he is classified by the College of Education, as a freshman, sophomore, junior, senior or graduate student.
8. Prior knowledge of general science as measured by the Cooperative General Science Test Advanced Form B.
9. The grade for which a student contracts for at the start of the semester.

The hypothesis was tested by using a step-wise multiple regression equation to predict the number of units completed. Similarly, additional hypotheses relating the stated variables and attitudes towards the course itself and the A-T method of instruction were tested by the multiple regression procedure. In all cases, a hypothesis was not rejected unless an F value was observed to be significant at or beyond the .05 level of confidence.

It was possible to formulate an equation that was significant beyond the .05 level of confidence in predicting the number of units a student would complete in a semester. While the entire equation (with the inclusion of all factors) was significant, there were certain variables that did not contribute a significant amount to the equation when they were added. There were five variables that contributed significantly to the prediction equation when they were added. These five variables were the student's cumulative grade point average, the number of science and/or mathematics courses a student has had in the past, the score of the student on the pretest achievement assessment, the class membership of the student, and the grade the student contracted for. These five factors contributed 29.62 percent of the observed variance.

Additional hypotheses stated that it would not be possible to predict the final attitude of the student toward the course or the method of instruction. The results of testing these hypotheses indicated that it was possible to predict the attitude of the student toward the course, but not toward the method of instruction.

There were three variables that were most influential in predicting the final attitude of the student toward the course: student attitude toward the course as measured by the pretest form of the Laboratory Attitude Inventory, the number of science and/or mathematics courses a student had previously taken, and the grade point average of the student. These three factors accounted for 26.65 percent of the observed variance.

PUPIL/SCIENCE TEACHER INTERPERSONAL COMPATIBILITY AND SCIENCE ATTITUDES

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Science education has experienced a change in instructional styles from a more traditional approach based almost solely on lecture to the discovery or inquiry approach with greater emphasis on lab work. As a result, the science teacher is assuming new roles and responsibilities in the classroom. The science teacher involved in the inquiry approach has more frequent interactions with individual students or with smaller groups of students. The purpose of this study was to examine the effects of pupil/science teacher interpersonal compatibility on science attitudes.

The sample included 13 classrooms and 7 different science teachers. All of the classes were using the New York State Earth Science Syllabus which is almost totally dependent upon student involvement in lab activities. In this type of class situation, pupil/teacher interaction is maximized. Students were pretested on the Science Attitude Scale (SAS) and the Self-Concept in Science Semantic Differential (SCSSD) during October, 1973. Also, the students and teachers completed the Fundamental Interpersonal Relations Orientation-Behavior (FIRO-B). From this measure, six pupil/teacher compatibility scores were calculated using the formulae developed by Schutz (1966). Students were posttested on the SAS and SCSSD in February, 1974. Gain scores were calculated from these two tests.

Correlational procedures were utilized to test the relationship between the gain in students' attitudes and the six measures of interpersonal compatibility between the science teacher and the students in each class. It was hypothesized that there would be a significant correlation between pupil/teacher compatibility and gain in students' attitude.

The six compatibility measures and the students' final average in eighth grade science were used as predictor variables in a stepwise multiple regression design. It was hypothesized that the seven predictor variables would account for a significant amount of variation in both of the two criterion variables as measured by gains from the SAS and the SCSSD.

PERFORMANCE VERSUS VERBAL ABILITY:
IMPLICATION FOR CURRICULUM BUILDING?

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Much emphasis has been placed upon the use of the "hands-on" approach to teaching science in the elementary and secondary schools in the past two decades. Piaget's developmental concept has found increased emphasis and importance over the past few years particularly with regard to the Science Curriculum Improvement Study (SCIS). The Elementary Science Study (ESS) materials use the child's interaction with material as a primary basis for science discovery activities. There are, however, some classroom practitioners who have observed that in such programs as ESS, SCIS, and others having a heavy reliance upon pupil interaction with materials, children having lesser verbal skills frequently achieve at a level equal to or above that of children with substantially higher verbal (academic) ability.

To investigate this phenomena two cohort groups of children from midwestern rural communities were selected for study using the criterion that their performance scale scores (Weschler) were found to be nine or more points below their verbal scale scores. The subjects identified represented all pupils with such differences in scale scores on the Weschler within the districts selected. No pupils with total Weschler scores below 75 were included; hence no child eligible for consideration for inclusion in special education due to mental retardation was included in the study group. Designating one group of children as the treatment group, members of the second group were matched as nearly as possible to the treatment group. A total of seventeen matched pairs thus resulted.

The treatment group was enrolled in a three year program (now in the final year) in which forty (40) percent of the instructional time was presented outside of their regular classroom by two specially trained teachers. The instructional program received by the treatment group consisted of heavy emphasis upon the use of concrete materials with the complete absence of abstractions and verbal symbols the first year (kindergarten) and no formal instruction in reading, writing, or number concepts. During the second year not more than ten (10) percent of the special instruction could be identified as being formal instruction in the three R's. During the present year less than twenty-five (25) percent of the instructional time can be identified as formal instruction in the three R's.

At the end of the second year no significant difference was found in the achievement scores in reading, spelling or arithmetic between the treatment and control groups. The criterion instrument was the Wide Range Achievement Test.

No significant differences were found in means on social, personal and school adjustment instruments between the treatment and control groups on pupil-marked scales. Teacher-marked Behavior Rating Scales indicated a substantial decline in the areas of social and school adjustment among the control group, while the treatment group teachers reported either essentially no change or slight improvement in these adjustment areas.

Although the results of this experiment are not conclusive at this time, some evidence exists to warrant further study and analysis. At the conclusion of the study, Spring 1974, more extensive reports will provide additional information which hopefully will shed more light on this interesting area of investigation.

STUDENT MISCONCEPTIONS IN CHEMICAL EQUILIBRIUM AS RELATED TO COGNITIVE LEVEL AND ACHIEVEMENT

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and
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Edmonton, Alberta, Canada

The purpose of this study was to determine the nature and extent of student misconceptions in chemical equilibrium and ascertain the degree to which certain misconceptions are related to performance on specific tasks involving cognitive transformations characteristic of the concrete and formal operational stages of thought.

Ninety-nine grade twelve chemistry students in four classes were administered the following test instruments:

1. The Misconception Identification Test (MIT) developed for this study. The MIT is a 30-item multiple choice test which requires the student to predict the effect of various variables on the equilibrium conditions of selected chemical systems involving homogeneous gas reactions, phase changes, and aqueous solutions of ionic solids. The six subtests of the MIT deal with the following six misconceptions: (1) mass vs. concentration, (2) rate vs. extent of reaction, (3) constant concentration, (4) misuse of Le Chatelier's Principle, (5) the constancy of the equilibrium "constant," and (6) competing equilibria.

2. An achievement test based on Chapters 7, 8, 9, and 10 of the CHEM Study text (KR-20=0.75).

3. Two combinatorial tasks involving the investigation of the nature of five colorless chemical solutions by manipulation of the various combinations of the solutions. Performance was evaluated on the basis of criteria outlined by Inhelder and Piaget.

4. A test consisting of three 15-item sections based on ten operations involving the four transformations of the INRC physical group model.

The MIT was scored according to two keys: accurately in the chemical sense, and according to the six major misconceptions identified by the instrument. Categorization as to the presence or absence of each misconception was made on the basis of both the performance and misconception scores for each student.

Item analysis of the MIT revealed that the probability of students choosing the keyed misconception response consistently exceeded that expected by chance alone (Chi square values for 25 of the item response distributions were significant at the $p < 0.01$ level). Eighty-two percent of the sample possessed three or more of the six misconceptions identified.

In terms of cognitive functioning, the sample was classified as follows: early concrete, 3 students; late concrete, 24 students; early formal, 61 students; and late formal, 11 students. Intercorrelations among the two forms of the MIT and the Piagetian tasks were all significant at the $p < 0.01$ level. Two specific misconceptions (1 and 2 above) were significantly related ($p < 0.05$) to cognitive level.

Correlations between the achievement scores and the Piagetian tasks were all significant at the $p < 0.05$ level, with performance on the tasks predicting 58.7 percent of the variance of the achievement scores.

Stepwise regression on the prediction of misconception scores revealed the achievement score to be the only significantly contributing predictor variable (R^2=26.4). Three of the six specific misconceptions (3, 4, and 6, above) were found to be related to achievement ($p < 0.05$).

CONTRIBUTED PAPERS II

Session C. Evaluation

Presiding: Louis A. Gatta, Deerfield High School, Deerfield, Illinois.

1. "A Study of the Effects of a Teacher Training Program on the Attitudes of Elementary School Students Towards Science." Francis X. Lawlor, Florida State University, Tallahassee, Florida.

2. "A Study of Planetarium Effectiveness on Student Achievement, Perceptions and Retention." Robert W. Ridky, University of Maryland, College Park, Maryland.

3. "Analysis of the Role of the Planetarium in Education." Dennis Sunal, University of Maryland, College Park, Maryland.

4. "An Analysis of Factors Successful in the Implementation of Innovative Science Programs in the Elementary and Secondary Rural Schools." Will L. Selser and Don Q. Milliken, Northeast Missouri State University, Kirksville, Missouri.

A STUDY OF THE EFFECTS OF A TEACHER TRAINING PROGRAM ON THE ATTITUDES OF ELEMENTARY SCHOOL STUDENTS TOWARDS SCIENCE

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In order to determine the effects of an in-service teacher training program in one of the NSF funded programs (SCIS), a study was made of the attitudes of elementary school students towards science as a school subject. In the first phase of the study, the subjects (756 students in the primary grades) were given a simple "favorite subject" questionnaire. The replies of students taught by participants were compared with replies from students taught by non-participating teachers. The students taught by participants liked science more than those taught by non-participants. The difference was significant.

A second phase of the study assessed the attitudes and perceptions of 921 fourth, fifth, and sixth grade pupils from 39 classes. An effort was made to match the classes in the sense that for each class taught by a participating teacher, a class was surveyed at the same grade level in the same school taught by a non-participating teacher. The population, in terms of science program experience, was more diverse than that used in Phase I. This diversity is shown in Table 1.

TEACHER PARTICIPANTS		TEACHER NON-PARTICIPANTS	
Group A	Group B	Group C	Group D
SCIS previously	No SCIS previously	SCIS now	No SCIS now
9 classes	13 classes	11 classes	6 classes
234 students	287 students	273 students	127 students

Table 1. Distribution of students in this study.

The additional comparisons possible with this population shed additional light on the effects of the teacher training program. (All but one of the contrasts of interest were significant.)

A pilot study was run to develop the instrument and the procedures. A simple questionnaire asked children to recall their earlier impression of science in school with five choices ranging from "horrible" to "great." The same question was asked to determine their impression of science this year. The second part of the questionnaire was open-ended: "Tell what you think." Four brief questions asked children to tell what they liked most and least about science previously and at present.

In brief, it was found that the attitude of students working with participating teachers was more favorable toward science than the attitudes of students working with non-participating teachers. This was true even though some non-participating teachers were teaching SCIS. There was also an improvement of attitude among students taught by participant teachers even when the students had had previous experience of the SCIS program. These findings are a strong indication that the classroom goals of the teacher training program had been achieved. The open-ended questions help to elucidate some of the factors responsible for these changes in student attitudes toward science.

A STUDY OF PLANETARIUM EFFECTIVENESS ON STUDENT ACHIEVEMENT, PERCEPTIONS AND RETENTION

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College Park, Maryland

The purpose of this study was to determine the effect of planetarium instruction in terms of immediate attainment, attitude and retention. Observations were made on three treatment groups at both the junior high school and college levels.

Treatment Group I received planetarium instruction consisting of one orientation session and five instructional sessions. Group II received five sessions of instruction dealing with the same concepts as in Group I but through activity inquiries drawn from nationally prominent curriculum projects. Group III received combined sessions of Groups I and II with concepts randomly assigned to the planetarium or classroom inquiry activities.

A pilot study using a Pretest-Posttest Control Group Design was conducted to establish the existence of a mystique effect and to determine if an orientation session prior to instruction is effective in minimizing this effect.

A Combined Multiple Time-Series, Pretest-Posttest three Group Design was used for content achievement and retention determination. In each case, investigator-developed instruments were administered six weeks later as a measure of retention. An astronomy related semantic differential instrument was designed to measure student perceptions in two broad areas; the unit of instruction and astronomy in society. Eighteen bipolar adjective pairs were used, with five response positions between each pair. All treatment groups rated five concepts over the scales on pre and post measures.

The Student's t distribution and t ratio were used to test for significant differences between means of treatment groups which experienced the orientation session and groups which did not. Analyses of variance and covariance were employed for testing hypotheses about differences in achievement and retention. Responses on a semantic differential instrument, used to measure astronomy perceptions, were factor analyzed using the principal components analysis. Factor loadings were obtained by varimax rotation.

The results of such analyses indicated:

1. The group which experienced the orientation session did significantly better on content learning than the group which did not.

2. The combined treatment group was the only group which significantly benefited from the treatment.

3. All groups showed minimal loss of content achievement on the retention test.

4. No interaction effect between treatment and retention was noticed on posttest data for the college treatment groups.

5. The planetarium group in both the junior high and college studies had the greatest positive perception change.

ANALYSIS OF THE ROLE OF THE PLANETARIUM IN EDUCATION

Dennis Sunal
University of Maryland
College Park, Maryland

Since its invention in the 1920's the planetarium's greatest potential was seen as an "educational tool." In more recent times, terms such as "theater of the skies " and "multimedia learning center" are used to describe the device and auxiliary instruments which have evolved. The increase of the planetarium in number to about 1000 in the United States and as a unique educational facility is said to be related to some of the most important problems in education during the last decade. In view of present limitations in educational monies, increased time demands for new curriculum content during the school day and accountability questions, it is important to evaluate what is known through research as to the actual role of the school and college associated planetarium in education.

The analysis and results of the role played by the planetarium in education concern three areas.

I. In addition to the physical facility and related school buildings, the goals and perceived role of the planetarium in education by planetarium educators are needed. Books, periodicals and other materials published since the opening of the first school associated planetarium in 1946 were researched for relevant statements which would permit the formulation of the perceived role by planetarium educators. A model for classification of educational goals was used to obtain a final summary in the cognitive, affective and process of investigative skill areas. The perceived role, in education, of the planetarium was found to include low level cognitive areas, receiving through valuing level goals in the affective area and all of the model process skill areas. These skills include the basic skills of observing, classifying, inferring, measuring, predicting, communicating, using space and time relationships and the integrated skills of interpreting data, hypothesizing, defining operationally, controlling variables, and experimenting.

II. A review of research performed with school associated planetariums was conducted for the purpose of determining the attainment, and weighing results, of the perceived goals of planetarium educators. The model for classification of educational goals described above was used in this process. Depending on the use of the planetarium in different situations all, some, or none of the perceived goals of planetarium educators were achieved. Little positive correlation was found among cognitive, affective or process skill areas.

III. Many of the experimental designs used in past planetarium research were of the pre-experimental type. These demonstrated strongly divergent points of view. Only recently have true-experimental and multiple time series designs been attempted. These later studies attempted dimensional relationships and interactions along many degrees of the experimental variables. Many of the early discrepancies are now seen to be easily included in a more generalized view concerning the actual role of the planetarium in education. In general, the planetarium session as typically experienced in present schools and universities does not produce changes (in participants in any area described by the model) significantly greater then that which can be obtained in ordinary classrooms without the planetarium projector.

AN ANALYSIS OF FACTORS SUCCESSFUL IN THE IMPLEMENTATION OF INNOVATIVE SCIENCE PROGRAMS IN THE ELEMENTARY AND SECONDARY RURAL SCHOOLS

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and

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This study identified and quantified factors successful in the implementation of Innovative Science Programs in thirty-one secondary rural schools in twenty-five counties of Northeast Missouri. Sixty-five secondary science teachers completed the Basic Secondary Questionnaire and thirty-four teachers from this group completed a second questionnaire entitled, "The Secondary Teacher's Interview In-Depth." Forty-six principals and/or superintendents of the participating schools completed the Secondary Administration Questionnaire. The questions were analyzed on a Burroughs B-3506 computer using standard correlation procedures as described by Guilford. Correlations were calculated in accordance with the MULRO-4 Program by F. J. Kelley.

Teacher factors identified as affecting implementation of innovative programs are the effect of college science content courses and science method courses, the teacher's feeling of adequacy in teaching science and the effect of administrative encouragement and the necessary financial support. Administrator factors identified are the administrator's role in initiating the programs and encouraging the teachers, the necessity of financial support, the relationship between the administrator's science background and his knowledge of the rationale and operation of innovative curricula.

Seventeen null hypotheses related to teacher factors in the implementation of innovative science programs in rural secondary schools were rejected either at a level of $p < .01$ or $p < .05$. These null hypotheses were stated as "the correlation between the occurrence of innovative science programs and . . ." Hypothesis number 1 concerned the type of degree held by the teacher; hypothesis numbers 2 and 13 dealt with the teacher's feeling of adequacy; hypothesis numbers 3, 4, 5, 6 and 7 dealt with the teacher's knowledge of the New Innovative Science Program (high school); hypothesis numbers 8 and 9 concerned the correlation of the teacher's receipt of literature concerning the new programs; hypothesis numbers 10, 11 and 12 dealt with the time factors devoted to science and laboratory classes; while hypothesis numbers 14, 15, 16 and 18 examined the financial and administrative encouragement factors as they related to the occurrence of Innovative Science Programs.

Seventeen null hypotheses, as they related to administrative factors in the implementation of innovative science programs in rural secondary schools, were rejected either at a level of $p < .01$ or $p < .05$. These null hypotheses were stated as "The correlation between the occurrence of the innovative science programs and ..." Hypothesis numbers 1, 2, 3 and 4 examined the correlation between the occurrence of innovative science programs and the receipt of literature concerning these programs; hypothesis number 5 was concerned with the administration's favorable reaction towards the new science program; hypothesis numbers 6, 7 and 8 quantified the relationship between the number of class periods per week, the approximate length of these class periods and the time devoted to innovative science laboratories; hypothesis number 9 established a positive relationship between the community involvement in science programs and the administrator's willingness to move in this direction; hypothesis numbers 10, 15, 16 and 17 examined the relationship of the administrator's academic background in science courses and how it affected the use of the Innovative Program; hypothesis numbers 11 and 12 reflect the impact of the administration's attitude toward the establishment of new programs; while hypothesis numbers 13 and 14 indicated the necessity for financial support in the establishment of innovative teaching techniques.

DISCUSSION PAPERS II

Session A. "A Comparison of Structured and Unstructured Modes of Teaching Science Process Activities."

Presiding: James P. Hale, Glencoe Public Schools, Glencoe, Illinois.

Authors: Robert K. Crocker, Harry G. Elliott, Kevin R. Bartlett, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

Session B. "A Comparison of Predicted Science Teaching Behaviors with a Theoretical Construct."

Presiding: Richard L. Sagness, University of South Dakota, Vermillion, South Dakota.

Author: Carl F. Berger, University of Michigan, Ann Arbor, Michigan.

Session C. "Learning Interference and Imagery Considerations Associated with Science Diagrams and Prose Media."

Presiding: John F. Schaff, University of Toledo, Toledo, Ohio.

Author: William G. Holliday, The University of Calgary, Calgary, Alberta, Canada.

DISCUSSION PAPERS II

Session D. "The Use of Film-Mediated Models to Prompt Children's Scientific Process Activities: A Pilot Study."

Presiding: Joseph D. Novak, Cornell University, Ithaca, New York.

Authors: John J. Koran, Jr. and Linda R. De Ture, University of Florida, Gainesville, Florida.

Session E. "The Science Education Doctorate: Competencies and Roles."

Presiding: Calvin Gale, Michigan Technological University, Houghton, Michigan.

Author: Ronald D. Anderson, University of Colorado, Boulder, Colorado.

A COMPARISON OF STRUCTURED AND UNSTRUCTURED MODES OF TEACHING SCIENCE PROCESS ACTIVITIES

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The purpose of the investigation was to explore the effects of two teaching modes on student achievement of science process skills and on student preference for teaching mode. Operationally, the distinction between teaching modes was based on the degree of teacher control of student investigations. In the unstructured mode, the teacher idenfied the area of investigation and supplied appropriate apparatus. In the structured mode, the teacher also controlled the specific arrangement of apparatus, the amount of data to be collected, and oriented student discussion in a particular direction. Null hypotheses were tested concerning the relative effectiveness of teaching modes and the interactions between teaching mode and a number of other independent variables, using achievement and preferance as criterion measures.

Four classes of grade six students were required to complete two sets of five science activities. Order of presentation of treatment, type of activity, and teachers were counterbalanced. The criterion measures consisted of two process achievement tests administered as pretests and posttests and a preference scale, in modified semantic differential format, administered following the completion of both sets of activities. The independent variables were treatment, sex, I.Q., creativity, personality (extraversion, neuroticism, and dependency), and socioeconomic status.

Achievement data were analyzed using multiple linear regression. It was found that, in general, subjects achieved better when taught in the structured mode. With respect to interaction effects, a significant interaction was found only between treatment and neuroticism. The existence of an apparently anomalous result for one of the classes led to the detection of a significant class by treatment interaction. This interaction could not be accounted for by reference to any of the variables measured but seemed to be related to previous achievement since the class that performed better in the unstructured mode was somewhat higher in previous achievement than the remaining classes.

Preference data were analyzed by developing frequency distributions for preference scores, cross tabulating by treatment and each of the other variables in turn, and computing the chi square statistic in each case. It was found that subjects exhibited a significant preference for the structured mode. It was also found that preference was significantly related to class and to I.Q.

A COMPARISON OF SCIENCE TEACHING BEHAVIORS WITH A THEORETICAL CONSTRUCT

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The objectives of the investigation were: 1) to find if elementary school teachers of science predict science teaching behaviors based on a particular situation or from one behavioral viewpoint; and 2) to compare teacher's predictions of teaching behaviors with a theoretical teaching strategy construct developed by the Science Curriculum Improvement Study (SCIS).

From the SCIS film "Don't Tell Me, I'll Find Out," nine scenes were selected reflecting the SCIS teaching strategy - exploration, invention and discovery. These scenes showed teachers: asking questions, answering questions, responding to student's comments, preparing for experiments, handling intellectual disagreements, handling organisms, distributing equipment and introducing concepts. Statements reflecting three kinds of teaching behaviors were submitted to an eight person SCIS judging panel. The behaviors were:

1) Teacher oriented - teacher decides next action or uses an immediate authority such as a book;
2) Student-teacher cooperation oriented - students and teacher jointly decide next action; and
3) Student oriented - teacher allows student to decide next action in class.

Statements were altered or eliminated until the judges had a Kendall Coefficient of concordance of .90 or better. Six statements relating to each scene, two of each orientation, were presented in a response pamphlet. Teachers predicted on an answer sheet their degree of agreement. Three scores were generated using the sums of degrees of agreement for each of the three kinds of behaviors.

The packet of materials (film, response pamphlet, and scoring sheet) was administered to 240 subjects, made up of the following groups:

69 Pre-service elementary methods students;
69 In-service teachers from four randomly chosen elementary schools;
57 In-service teachers completing a two week or four week SCIS - CCSS institute;
45 In-service teachers who had taught the SCIS materials for one or two school years.

Profile analysis indicated that teachers predicted their behaviors on a particular event or situation rather than with a constant behavior orientation. Three characteristic profile curves emerged. All indicated low agreement with teacher oriented decisions but differed in the inflection of the profiles and the preference for student teacher cooperation or student oriented scores. The three kinds of profiles were consistent within the SCIS staff and in-service teachers who had completed workshops and/or taught SCIS for over two years.

To find if the predictions reported by the teacher matched the theoretical construct, a principle component analysis was run. Four components emerged. Of the four components three explained 100 percent of the variance. The first component showed high correlation with all scores,but highest with the sum of all scores. It was interpreted as the degree of agreement component. The second component had a high positive correlation with the student oriented score and a high negative correlation with the teacher oriented score and was interpreted as a student positive teacher negative oriented component. The third had high correlation with the student-teacher cooperation oriented score and was interpreted as the student-teacher cooperation component. Thus, the components directly supported the theoretical construct. Traditional test analyses were performed which showed the PRM had a split halves reliability of 0.84 and predicted to observed behavior validity correlation of 0.74.

It may be concluded that it is possible to develop a secondary device to measure teacher behavior that could support other interaction analysis techniques. Such secondary devices can be validated against theoretical constructs. Because teachers predict differing behaviors, curriculum developers may expect and utilize differing behaviors for teachers. Most importantly, it may be possible to use such a device to test whether teachers change their predicted behavior based upon education and/or experiences with a new curriculum.

LEARNING INTERFERENCE AND IMAGERY CONSIDERATIONS ASSOCIATED WITH SCIENCE DIAGRAMS AND PROSE MEDIA

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Word and picture-word science diagrams* (e.g., B.S.C.S. - 1973: Yellow Version, p. 556; Green Version, p. 225) are commonly found adjacent to descriptive prose in science textbooks. If an instructional technique could be developed whereby the learner would effectively attend to these diagrams, designers of science instruction could better capitalize on the potential image-evoking quality of this picture type. These instructional diagrams usually present paired relationships among concepts (e.g., chlorophyll, ATP) constituting relatively higher order concepts (e.g., energy relationships in life). According to theories of psychological imagery, learners are more likely to remember certain pictorial displays relative to certain verbal displays.

It was hypothesized that the placement of adjunct verbal questions adjacent to either a word or picture-word science diagram would positively influence the learner's inspection behavior of these instructional materials. Consequently, the learner would more effectively remember certain conceptual relationships displayed in the diagram relative to a concise prose description of the same information. In addition, a certain multi-media or combination of prose adjacent to the diagram would result in learning interference because of the distracting quality of prose stimuli. This second hypothesis is based on Fleming's discussion regarding the ineffectual use of instructional pictures observed in students on this continent and the learner's general insistence on using prose to discover verbal information.

Twenty-two adjunct verbal questions represented the instructive technique used to direct the learner's attention to the science diagrams and prose materials in all treatment groups. Thirty multiple choice, verbal criterion test items were developed from translated or rephrased adjunct verbal questions presented in the instruction. The five treatments were (1) word (black and white, block) diagram (WD), (2) word diagram with prose (WD-P), (3) picture-word (colored, stylized) diagram (WD), (4) picture-word diagram with prose (PWD-P), and (5) prose (P). Both diagrams contained the same words identifying concepts associated with certain biogeochemical cycles. The same word diagram, picture-word diagram, prose, and adjunct question set were used throughout the experiment.

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* pathway or cyclic schema

Face validity was confirmed through personally conducted interviews of thirty-three high school biology teachers. Two hundred seven high school biology students were randomly assigned to the five treatments.

Four orthogonal comparisons of the means ($p < .05$) supported the two *a priori* hypotheses. The word and picture-word science diagram treatments were independently more effective than a prose description (WD > P, PWD > P). In addition, the word and picture-word diagrams were independently more effective than the multi-media or combination of the same diagram and prose (WD > WD-P, PWD > PWD-P).

The educational significance of this study is two-fold. First, a science diagram type can be a more effective medium than concise science prose in terms of the described experiment. These results provide selective generalizing support for many of the highly structured laboratory experiments in psychological imagery to a situation more closely related to science instruction in the classroom. Second, the effectiveness of certain multi-media science instructional presentations can result in learning interference. These findings have implications regarding the general use of multi-media instruction, an almost universal practice in science education.

THE USE OF FILM MEDIATED MODELS TO PROMPT CHILDREN'S SCIENTIFIC PROCESS ACTIVITIES: A PILOT STUDY

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There is considerable evidence to suggest that children's behavior, and adults' behavior, can be influenced by live, film-mediated and symbolic models. This research encompasses counseling, teacher education, and other areas where behavior modification is sought. In all of these studies subjects are exposed to a model performing certain clearly defined behaviors and the learner acquires the observed behaviors without having to either overtly respond to the model's behavior or be reinforced for performing this behavior during acquisition. The implication of this research for science learning is that models of scientific process activities, either live or film-mediated, either teacher or student, can be devised to prompt children to engage in observing, classifying, inferring, predicting, hypothesizing, experimenting, gathering data, interpreting data, and communicating results.

In a pilot study designed to determine whether fourth grade students can acquire a set of behaviors related to performing certain laboratory activities, 22 students were randomly assigned to either a film-mediated modeling treatment or a control. Students in the treatment viewed a videotape model showing peer leaders engaging in the steps of an experiment and verbalizing their acts. The control students did not view the model. Subsequently, the students of both groups conducted the same experiment in class while trained raters observed their behavior. (Inter-rater Reliability was between .87 - .96.) Although both groups of students received preliminary verbal instructions regarding how to conduct the experiment, those students who viewed the model after the directions produced significantly more positive behaviors ($p < .05$) and fewer negative behaviors ($p < .05$) than the control group that did not view the model, but had an equivalent time to practice the directions prior to, and during, the laboratory session.

The implications of this study are that: 1) children may be taught experimental process activities through observational learning; and 2) film-mediated models accompanying verbal directions appear to have a greater positive effect than verbal directions and practice alone during process oriented lessons. Preliminary data also suggest that modeling may be an efficient and effective method of communicating skills to low verbal students. Although further research is necessary, these preliminary results appear promising and consistent with previous research and theory and suggest a more extensive line of research exploring the acquisition of other scientific process activities, both verbal and non-verbal, through variations on the observational learning model, and explorations of student aptitudes as channels of effective learning.

THE SCIENCE EDUCATION DOCTORATE: COMPETENCIES AND ROLES

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Although substantially based on the results of empirical inquiry, this paper is basically a position statement dealing with doctoral programs in science education. Research, conducted by the author and others, is reported which identifies major professional employment activities for recipients of the doctorate in terms of the specific tasks involved in these jobs and the specific competencies required to engage in these tasks. In addition, other research is reviewed which provides important guidelines for the success of doctoral programs with various areas of emphasis.

The major recommendation of the paper is that the specific focus or foci of doctoral programs be identified and each program developed in the specified areas. The three areas of emphasis identified are (a) research and evaluation, (b) development, and (c) instructional leadership. Examples of the specific competencies of personnel employed in these areas are reported. The other research cited in the paper points to the necessity of incorporating into doctoral programs such facets as substantial and appropriate apprenticeship experiences, the appropriate "climate," and the selection of students with socialization that is related to the nature of the program. Implications of the research cited are discussed.

CONTRIBUTED PAPERS III

Session A. Instructional Procedures

Presiding: Charles A. Wall, Salisbury State College, Salisbury, Maryland.

1. "The Effect of Prior Knowledge and Critical Thinking on the Interpretation of a Biological Concept Using an Advance Organizer." George P. Toth and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.

2. "Preconditions for use of an Advance Organizer in Teaching the Principle of Natural Selection." H. Craig Sipe and James H. Houghton, State University of New York at Albany, Albany, New York.

3. "Interaction Patterns and Their Relationship with Outcomes in Australian Science Education Project Classrooms." Olin N. Power, University of Queensland, St. Lucia, 4067, Australia.

4. "The Effect of Questioning Upon Various Cognitive Levels of Student Performance." Alexandria Martikean and Larry Guthrie, Indiana University Northwest, Gary, Indiana

THE EFFECT OF PRIOR KNOWLEDGE AND CRITICAL THINKING ON THE INTERPRETATION OF A BIOLOGICAL CONCEPT USING AN ADVANCE ORGANIZER

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and

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The purpose of this study was to investigate the effects of certain entering behaviors, more specifically, critical thinking and prior knowledge, on the interpretation of a biological concept using an advance organizer. This research was designed to determine whether these two entering behaviors assist in the learning of new meaningful material.

The need for this experimental research was based on the premise that meaningful learning or the acquisition of meanings takes place in particular learners. If meaningful learning is to occur, the cognitive structure of the particular individual must include the relevant "ideational content and the requisite intellectual abilities." The potential meaningfulness of learning material will necessarily vary with certain factors including age, IQ, and subject-matter sophistication. Those specific cognitive characteristics that do contribute to meaningful learning, however, are never identified.

The subjects for this study consisted of 136 ninth grade students enrolled in BSCS Biology (Green Version). Prior to instruction Ss were administered the "Cornell Critical Thinking Test, Level X" to determine high and low levels of critical thinking. All Ss were also given a 50-item multiple-choice test (reliability = .84) on "Populations and Ecosystems" to determine prior knowledge. A 25-item multiple-choice test (reliability = .77) on "Man and Populations" was administered as the criterion test after the treatment. Both tests were developed from items included in the BSCS "Reference Book of Test Items for High School Biology." Treatment consisted of all Ss reading a 2700 word passage on "Man and the Biological Community" as adapted from BSCS Biology (Green Version). One half of Ss read a 350 word advance organizer prior to the treatment, and the other half read a comparable length historical passage prior to the treatment. The dependent variable, as measured by the 25-item achievement test, was analyzed within a 2 x 2 factorial design which consisted of two levels of critical thinking (high and low) and two levels of instruction (with advance organizer and with historical passage). ANOVA procedures were employed for the statistical analyses for the preliminary data reported in this paper.

The results of the above analyses indicate that high critical thinkers scored significantly higher (.01 level) than low critical thinkers on the criterion test. Similarly, Ss who scored high on the test for prior knowledge also scored significantly higher on the criterion test at the .01 level. The hypotheses that the high and low critical thinkers and the high and low scorers of prior knowledge were randomly selected from the same population were thus rejected in factor of the higher groups. Interaction between critical thinking levels (high and low) and the two levels of instruction was not significant at the .01 level. No significant difference between the advance organizer group and the historical passage group was observed.

The results obtained in this study appear to dispute the necessity of advance organizers to make new material more meaningful. The results further provide a possible definition to several particular "requisite intellectual abilities" that enhance the acquisition of meaningful material.

PRECONDITIONS FOR USE OF AN ADVANCE ORGANIZER IN TEACHING THE PRINCIPLE OF NATURAL SELECTION

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What general procedures make for meaningful verbal learning? Assuming that the application of such learning is either in the application of a rule or a principle or in the solution of a novel problem, is it desirable to provide for prior and/or prerequisite information?

Theoretically the research reported pertains to the findings of Ausubel et al. on advance organizers, Gagne et al. on task analysis strategies, Morrison et al. on formal logical presentations, Underwood et al. on paired associate learning, and Piaget et al. on a developmental model for intelligence. Practically, the investigation has implications for the design of instructional sequences.

The subjects were 96 tenth-grade biology students attending a suburban school, selected to have equal numbers of pupils with concrete and formal operational capabilities. These, in turn, were assigned randomly to four treatment groups (task analysis, logical presentation, rote, and control) for instruction on a one-to-one basis in the principle of natural selection--an advance organizer appropriate for facilitating the retrieval and application of information. The criterion measures consisted of the Natural Selection Test (NST) requiring the application of the principle to a novel relevant situation and the Study Passage Test (SPT) requiring the recall of information and the interpretation of passages related to melanism in moths and radiation in Australian marsupials. The tests were administered jointly and twice, within two days of the instruction and approximately two weeks later.

The experimental design can be classified as 2 x 4 x 2 repeated measures. The statistical treatment was analysis of variance. Null hypothesis concerning (1) difference between treatment means, (2) means for the concrete and formal operations categories, and (3) interactions between the treatments and developmental variables were tested for each of two criterion measures (NST, SPT) when administered as post-treatment and post post-treatment assessments. Tukey's A procedure was used to make a post-hoc comparison of the non-orthoganal mean pairs. The 0.05 level of significance was used in all comparisons.

In brief, the findings confirm that (1) using a task analysis or logical presentation procedure (in that order) for instruction in establishing meaning within the principle of natural selection was efficacious; (2) the formal operations group had a higher mean score on the test (SPT) related to recall of fact and interpretation of terms; (3) elapsed time was a significant factor on the SPT, but not on the NST measure dealing with application of knowledge, and (4) the interaction of treatments and developmental stages was indeterminate.

The findings of the study imply that (1) care should be given to the design of instruction prior to the use of the characteristically abstract principles; (2) the constructs used in explaining recall of information and application of information over short-term and long-term retention periods should be examined; (3) there is reason for exploring the applicability of the general findings to a wide range of subject matter and degree of abstraction; and (4) there is need to examine further the constructs for developmental learning and instructional planning.

INTERACTION PATTERNS AND THEIR RELATIONSHIP WITH OUTCOMES IN AUSTRALIAN SCIENCE EDUCATION PROJECT CLASSROOMS

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Little is known regarding the relationships between teacher behavior, classroom environment and outcomes of instruction in other than conventional teacher-centered classrooms. In this study an attempt was made (a) to describe the nature of teacher-pupil-materials interactions occurring in classrooms using Australian Science Education Project (ASEP) materials, (b) to study relationships among these interaction patterns; changes in student achievement, attitudes towards science and perceptions of the learning environment, and teacher values.

Two scales measuring teacher values relating to classroom behavior and curriculum emphasis were administered to 16 ASEP staff members, 73 science education majors and a random sample of 68 grade nine science teachers. Clusters of individuals representing different values about teaching and curricula were established. Twenty-one teachers and science education majors were selected so that several representatives of each cluster were included in the study. These persons were asked to use the ASEP unit "Light Forms Images" with their classes.

Three of the five lessons required to complete the core material in the unit were videorecorded. The videotapes were analyzed using a classroom behavior coding scheme (SABIC) designed especially for this study. Achievement and attitude pre-tests were administered before teaching on the unit, and post-tests (achievement, attitude towards science lessons, Class Activities Questionnaire) were administered on the sixth lesson.

Regression analysis techniques were used to determine relationships among interaction patterns and adjusted post-test measures, with the class as the unit of analysis. Results obtained indicate that:

(a) a sizeable proportion of teachers do not express values congruent with those of ASEP.
(b) teacher values play an important role in establishing a learning environment - i.e. the patterns of interaction occurring in the classroom.
(c) interaction patterns in ASEP classrooms are dissimilar to those occurring in more conventional programs .

(d) several behavioral measures were found to be associated with student cognitive gains, (e.g. amount of teacher-class, teacher-material interaction; unrelated activity) attitudinal changes, and student perceptions of the classroom - not always in the anticipated manner.

(e) the more teacher dominated and subject oriented the classroom, the more negative student attitudes towards science; however, a certain amount of teacher structuring appears to facilitate achievement.

THE EFFECT OF QUESTIONING UPON VARIOUS COGNITIVE LEVELS OF STUDENT PERFORMANCE

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and

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Indiana University Northwest
Gary, Indiana

A study of the levels of questioning and their effects upon student performance at each of the six levels of Bloom's Taxonomy of Educational Objectives was conducted. A four week botany unit was studied by two groups (fifteen per group) of eight and nine year old children in the third and fourth grades at Lew Wallace Elementary School in Hammond, Indiana.

Instruction in the control group centered on the use of cognitive memory questions, i.e., the use of questioning strategies requiring recall information. Dominant emphasis of instruction in the experimental group centered on the use of cognitive level questions above the stage of recall. Gain scores for both groups were significant at the .05 level. Comparisons of control and experimental groups, however, yielded no significant differences between groups. The comparisons were based upon applying a t-test to mean group scores obtained on teacher made pre- and post-tests reflecting the six levels of Bloom's Taxonomy of Educational Objectives. Intragroup scores and percent of points received by each group for each test item on the pre- and post-tests were also analyzed.

The extent to which the null hypothesis is supported may have its strongest explanation in Piaget's conceptualizations. Piaget's position with regard to the cognitive development of children generally indicates that all children progress through certain stages of intellectual development, and progress from stage to stage is the same for every child.

If for the purpose of discussion, it is assumed that the cognitive development of the sample population used in the study generally reflected the cognitive behaviors attributed to children at the concrete operational stage, then it would seem that the nature of the questions posed to the experimental group may have been too abstract; and that the impact of various high level questioning strategies may best be realized only after children reach the formal operations stage.

Findings obtained from the study would seem to support Piaget's position with regard to the cognitive development of children. Posttest results illustrate an inverse ratio between the levels of questioning as indicated by Bloom's Taxonomy of Educational Objectives and correct responses obtained by both groups.

THE DEVELOPMENT AND FIELD TESTING OF A SCIENCE CLASSROOM OBSERVATION FORM (SCOF)

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and

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The purpose of this study was to develop and field-test an instrument focusing on the interactive characteristics among students, the environment and teacher in elementary and junior high school science classrooms. It was developed as a research instrument to provide a measure of the degree of openness and inquiry orientation within a classroom.

The characteristics of classroom interaction to be rated were identified by an examination of the literature describing inquiry, discovery learning as well as child and material centered science. A pool of over 200 statements was assessed by a panel of judges and reduced to approximately 50 items to be rated by an observer on a 5 point Likert scale. The instrument was then used in a pilot study by a team of observers in several junior high school classrooms. From this data ambiguous items were redrafted, checks were made on the inter-observer reliability and procedures for training future observers developed. The classrooms used in this pilot study were selected to provide a spectrum ranging from open, inquiry oriented classrooms to closed lecture oriented situations.

The final instrument contained 39 items on which an observer rated a science classroom. For observer convenience, the items were placed in one of three categories: environment, teacher or the student. SCOF was then used to rate the interactive characteristics of 43 junior high school science classrooms with at least two observers in each classroom on at least three separate occasions. At the same time data concerning student attitudes, interests and cognitive attributes were gathered along with information relating to implementation of an inquiry oriented program.

A reliability of .93 and an inter-observer consistency of .86 were obtained using the total SCOF instrument. Through factor analysis eight factors were identified that could be interpreted. Tentative interpretations include "student-environment interaction," "cohesive interests and attitudes," "student centeredness," "teacher, subject centeredness," "student authenticity," "non-interactive anomie," "student interactive dynamism" and a possible "pseudo inquiry factor." Three second order factors emerged "authentic

CONTRIBUTED PAPERS III

Session B. Instrumentation and Test Construction

Presiding: James P. Barufaldi, University of Texas at Austin, Austin, Texas.

1. "The Development and Field Testing of a Science Classroom Observation Form (SCOF)." Richard L. Butt, McGill University, Montreal H3a 1Y2, Quebec, Canada and Marvin F. Wideen, Simon Fraser University, Burnaby 2, British Columbia.

2. "A Search for Subscales in the Science Process Inventory." Gary C. Bates, Harvard University, Cambridge, Massachusetts.

3. "The Development of an Instrument to Evaluate Chemistry Laboratory Skills." Robert J. Hearle, University of Maryland, Beltsville, Maryland.

4. "A Factor Analysis and Partial Validation of the Moore Sutman Inventory of Scientific Attitudes." Marvin F. Wideen, Simon Fraser University, Burnaby 2, British Columbia and Richard L. Butt, McGill University, Montreal H3A 1Y2, Quebec, Canada.

interaction," and "teacher-subject centeredness" are tentative interpretations of two factors. The relationship of these to student outcomes is described in the paper.

Significant correlations were obtained between the total SCOF score and a measure of program implementation. SCOF scores were also positively related to a measure of the student's perception of the science classroom.

A SEARCH FOR SUBSCALES IN THE SCIENCE PROCESS INVENTORY

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During the decade of the 60's several instruments were developed to assess students' knowledge about the nature and processes of science. A common practice in developing one type of these instruments was to draw a number of statements from the writings of historians and philosophers of science. Students are then asked to agree or disagree with each statement. In general, several themes are included in the instrument and a number of items relate to each theme. For example, in the Science Process Inventory, Form D (SPI), the author provides the following subdivision:

I - Assumptions	17,22,27
A-Reality	69,72,73,76,104
B-Intelligibility	74,75,77
C-Consistency	12,63,109,114,119,126,127
D-Causality	20,66,67,68,70,71,123

Although a multitude of themes are identified in the development of the instrument, only a single total score is reported. (A few instruments do provide two or three subscales, e.g. Test on Understanding (3), Facts About Science (2), and Test on the Social Aspects of Science (3).) This means that a great deal of information about the specific themes which students understand or misunderstand is lost. This more detailed information would be of great value to both teachers and curriculum planners.

In hope of providing science educators with more specific information on students' knowledge about the nature and processes of science, we have undertaken a careful analysis of the SPI in an attempt to develop a number of subscales for this instrument.

SPI, Form D, was chosen because it purports to sample a large number of themes and because student responses are available from the large national random sample of high school physics classes used in the 1967-68 Harvard Project Physics Summative Evaluation. A subsample of 500 students who took both the pre and post tests of SPI was split in half. The first half was used to identify the subscales, while the second half served as a check on the reliability of the scales. Analysis was carried out both for individual scores and class means. Earlier work, by Gary Anderson, with the Learning Environment Inventory suggests that suitable reliabilities can be achieved on multiple subscale instruments using six or seven items per scale only for class means. However, information at the class level is still of considerable significance in planning and evaluation. An earlier factor analysis of several of the SPI items by Aikenhead suggests that many of these items have a strong common component. Therefore a more sophisticated type of instrument may have to be developed if science educators are to obtain more specific and detailed information in this area.

THE DEVELOPMENT OF AN INSTRUMENT TO EVALUATE CHEMISTRY LABORATORY SKILLS

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Many curriculum project evaluators, science educators and science teachers have pointed out the need to evaluate laboratory skills. The CHEM Study program and other newer curriculum projects made limited evaluation efforts, but these efforts were limited in scope and applicability to the actual needs of teachers and science education researchers.

The chemistry laboratory represents an organized learning experience that is often used to support or develop course content as well as add to a student's knowledge of scientific procedures. As such, the laboratory contains performance objectives that can be identified and measured. These objectives take the form of skills or processes that are developed and used by students in carrying out laboratory experiments. This study was concerned with the identification of skills and construction of tests to measure their achievement.

Prior to construction of the laboratory skills tests an analysis of widely used high school laboratory manuals was carried out to identify the skills needed to execute chemistry experiments. The skills were then grouped into eight major categories, each with a different number of subgroups. The completed skills list was then submitted to selected science educators and chemistry teachers for their analysis. Following this analysis, the list was revised and rechecked against the laboratory manuals to determine the frequency of occurrence of each skill. The revised list with observed frequencies was then used as the basis for constructing a prototype evaluation instrument. The instrument was then field-tested in twenty schools in Maryland, Virginia, and Washington, D.C. Difficulty, discrimination and internal validity were determined for each test item and overall test reliability was calculated. Using this data as well as classroom teacher feedback, the test was revised.

The revised test contains 36 items and is divided into two parts. Part A contains manipulative questions designed to measure the student's ability to identify and use laboratory equipment in collecting data. Part B contains questions that are mainly cognitive in content and are designed to measure student's ability to organize and summarize data, draw conclusions and design further experiments. Both parts utilize the multiple choice format, although several questions in Part A require the student to record data on the back of the answer sheet. Such data include the weights or volumes of objects as determined by the students. A pretest was prepared by randomly selecting 13 items from both parts of the larger 36 item test.

The completed test instruments were then administered to over 1500 chemistry students in a study to measure the achievement of laboratory skills by chemistry students and to determine the influence of sex of the student and chemistry curriculum studied in learning laboratory skills. In addition the correlation between learning subject matter and learning laboratory skills was also investigated.

The results of the above study as they pertain to the test instrument have demonstrated that it is possible to construct tests of laboratory skills that are characterized by high content validity and acceptable reliability. The reliability of the test was 0.7 and is influenced by the inclusion of several mastery type items from the manipulative portion of the test. The skills were mastered by most students and hence had low difficulty which thus lowered overall test reliability. Mean score for the 36 item test was 21.6 with the majority of test items having a difficulty between 0.3 - 0.6 and discrimination between 0.1 - 0.3. The test was found to have high content validity as determined by a panel of science educators and chemistry teachers.

The tests also provide the teacher with a large number and diversity of test questions, opportunity to choose appropriate testing materials, uniformity of testing environment and flexibility to use test results for evaluative or diagnostic purposes. Their enthusiastic reception by both teachers and students alike lend additional support to their use.

The development of laboratory skills test instruments and their use in the previously mentioned study has indicated that:

Additional tests of laboratory skills in other science areas need to be developed.

A correlation between performance on the skills test and other "processes of science" instruments needs to be determined.

Further studies need to be conducted to determine what characteristics of the curriculum, student and teacher lead to more effective teaching and learning of laboratory skills.

A FACTOR ANALYSIS AND PARTIAL VALIDATION OF THE MOORE SUTMAN INVENTORY OF SCIENTIFIC ATTITUDES

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and

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Montreal, Quebec, Canada

The need for the development of instruments in the affective domain has frequently been expressed. An equally compelling need is to subject existing measures to a variety of empirical analyses to gain a better understanding of their strengths and weaknesses and to contribute to an increasing bank of information available concerning the validity of each different measure. The purpose of this inquiry was to subject the Moore Sutman attitude inventory to an empirical analysis with three questions in mind. First, could the original attitudes or position statements around which the instrument was developed be substantiated through factor analysis? Second, are the scores from this instrument related to scores on interest, classroom perception and cognitive measures? Third, are the scores related to sex, grade, and the program involvement of students?

The Moore Sutman attitude inventory was developed around six position statements representing intellectual attitudes and six, representing emotional attitudes. It was field-tested and validated in two administrations to three groups of students who received different types of instruction relative to the attitudes involved. Since the changes in pre-test to post-test were in keeping with the original hypothesis, a measure of construct validity was claimed.

In this inquiry, the attitude inventory was administered to 1165 seventh, eighth and ninth grade students along with measures of interest,classroom perception and cognitive ability. Data were also collected on the sex, grade, and program involvement of the students. A principal components factor analysis was conducted using the raw data from the attitude scale. Inter-correlations were run among the total scores from the measures given as well as sex and grade. The mean values of the total score from the attitude inventory were calculated for the different groups categorized according to their program involvement. An analysis of variance was run using sex, expressed interest and grade as main effects and the attitude scores as the dependent variable. The data sources were students in classrooms selected at random from schools in the Province of Saskatchewan. A variety of programs including IPS and ESCP were in use throughout the three grades sampled.

The results of the factor analysis indicated that the original position statements or attitudes could not be substantiated. However, the item clusters provide a basis for useful subscales within the text. The scores from the scale had a low positive correlation with measures of cognitive ability and classroom atmosphere. The overall relationship between attitude scores and the students' sex and grade were not significant through correlation coefficients. However, through analysis of variance it was found that the attitude scores of girls expressing an interest in science was higher than those expressing an interest in other subjects. The attitude scores of boys remained about the same regardless of their subject interest.

CONTRIBUTED PAPERS III

Session C. Teacher Characteristics

Presiding: Bill Tillery, Arizona State University, Tempe, Arizona.

1. "Relationships Between Progressivism, Traditionalism, Dogmatism, and Philosophical Consistency in Science, English and Elementary School Teachers." Lewis M. Brown, New Mexico State University, Farmington, New Mexico.

2. "Concepts of Science and Scientists Among Prospective Elementary Teachers." R. G. E. Mitias, Ohio University, Athens, Ohio.

3. "Path Analysis of Selected Teacher Variables from Public Elementary Schools of the New England, the Mideast, and the Southwest Regions of the United States During the 1970-1971 School Year." Bess J. Nelson, The Ohio State University, Columbus, Ohio.

4. "The Prediction of Subject Matter Bias Related to Science in the Elementary Schools." Fred L. Prince, University of South Florida, Tampa, Florida.

RELATIONSHIPS BETWEEN PROGRESSIVISM, TRADITIONALISM, DOGMATISM, AND PHILOSOPHICAL CONSISTENCY IN SCIENCE, ENGLISH AND ELEMENTARY SCHOOL TEACHERS

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This paper is concerned with the delineation of relationships among teacher attitudes on progressive and traditional teaching ideologies, personal philosophical orientation, and degree of individual differences in openness or closedness of belief systems. More specifically, a relationship was sought between a particular teaching ideology, progressivism, and a particular personal philosophical orientation, existentialism, with the expectation that one may be indicative or perhaps predictive of the other.

Additionally, an attempt was made to isolate differences in progressive and traditional teaching ideologies, personal philosophical orientation, degree of differences in openness or closedness of belief systems, and degree of difference in pseudoprogressivism among four subgroups consisting of secondary science teachers, secondary science student teachers, secondary English teachers, and elementary teachers.

The population, consisting of seventy volunteering teachers, was individually, and without time limit, administered three instruments: the Hug Philosophical Consistency Test, and Rokeach Dogmatism Scale, and the Kerlinger Education Scale I.

Multi-linear stepwise regression analysis and analysis of variance were used to determine predictive value of life philosophy upon educational attitude and to determine differences among the four teacher subgroups on Kerlinger Scale and Hug scores.

Significant differences between any pairs of groups on the Kerlinger and Rokeach instruments, including analysis involving pseudoprogressivism, were determined through the use of t - statistics.

The results of the study indicate that teachers harboring progressive educational attitudes are in agreement with existential philosophical ideologies and teachers harboring traditional educational attitudes are in disagreement with existentialism. It was found that agreement and disagreement scores on the existentialism portion of the Hug test are predictive of progressive and traditional educational attitude.

Results also indicate that there are significant differences in educational attitude, philosophical orientation, and degree of openness or closedness of belief systems, among the four teacher subgroups. Science teachers and student teachers were significantly more experimentalist than were English and elementary teachers, while English teachers were in significantly greater agreement with existentialism then were science teachers. In addition, science teachers assessed to harbor progressive educational attitudes were significantly more traditional than English and elementary progressives. The science teachers and student teachers exhibited a much greater degree of pseudoprogressivism than did the other teacher subgroups, while the elementary sample was found to be significantly less traditional than the secondary science sample and the combined secondary science and English sample.

CONCEPTS OF SCIENCE AND SCIENTISTS
AMONG PROSPECTIVE ELEMENTARY TEACHERS

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Stress has been placed on science teaching at the elementary school level. Consequently a diversity of new approaches and curricula were developed to help expand interest in science among elementary school pupils. One major factor in the teaching/learning situation is the teacher's concepts of a given discipline (science, mathematics, English, etc.) and his/her attitude toward the discipline. Such concepts and attitudes affect teacher performance which in turn affect pupils' concepts, attitudes and the learning outcome. Therefore, this study attempted to answer the following questions: (1) What concepts did a sample of prospective elementary teachers hold of science and scientists? (2) What attitudinal qualities did the various concepts reflect? (3) How did the results of this study compare with those of an earlier one reported in the literature?

This investigation included college students who were enrolled in elementary methods courses (reading, social studies and mathematics) at Ohio University (Athens, Ohio). All subjects were juniors and seniors. Incomplete Sentence technique and two Lists of Concepts of Science (LOCOS I) and Scientists (LOCOS II) were used. Subjects were to complete the two incomplete sentences first. LOCOS I and II were distributed afterwards. The subjects were then asked to match their completed concepts of science and scientists with the most similar concept on LOCOS I and LOCOS II respectively. Space was provided for writing in concepts which did not appear on LOCOS I and II. The frequencies of each concept were, then, totaled and their percentages calculated. Concepts were further examined in terms of their positive, neutral or negative attitudinal quality. Results were tabulated and then compared with those of an earlier study (Mitias, Journal of Research in Science Teaching, 1970, pp. 135-140).

(1) The subjects' concepts of science showed broad diversity. This ranged from science as an art to science as consensus of public opinion. (2) Concepts of scientists varied widely from a person who helps others to an ego-maniac who does not believe in God. (3) The attitudinal qualities of concepts of science showed the largest percentage to be neutral, followed by positive concepts far behind, and trailed by negative ones. (4) The highest percentage of concepts of scientists had a neutral attitudinal quality, followed by positive concepts far behind and trailed by concepts of negative attitudinal quality. (5) Compared to an earlier study (1967-68), this group showed a more neutral attitude toward science and scientists with less positive and less negative attitudes toward both.

PATH ANALYSIS OF SELECTED TEACHER VARIABLES FROM PUBLIC ELEMENTARY SCHOOLS OF THE NEW ENGLAND, THE MIDEAST, AND THE SOUTHWEST REGIONS OF THE UNITED STATES DURING THE 1970-1971 SCHOOL YEAR

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The purpose of this study was to determine if models could be developed to explain possible directional effects of science-teacher characteristics, science-class characteristics, availability of science instructional materials, and factors which limit teaching effectiveness on science-teaching practices and/or teacher satisfaction with teaching science in the New England, the Mideast, and the Southwest Regions of the United States during the 1970-1971 school year.

The population for this study consisted of all of the public elementary schools in the six states in the New England Region, the District of Columbia and the five states in the Mideast Region, and the four states in the Southwest Region of the United States. The sample of the study consisted of 2,948 randomly chosen public elementary schools from which a teacher was randomly selected to respond to a questionnaire. The teachers randomly selected the science class upon which to focus in responding to some items in the questionnaires.

Data for this study were obtained from selected Elementary Teacher Questionnaire items. Items in the Questionnaire pertained to science-teaching practices, science teacher characteristics, science class characteristics, availability of science instructional materials, factors which limit teaching effectiveness, and teacher satisfaction with teaching science. Usable Questionnaires were received from teachers from about 30 percent of the schools sampled.

Factor analysis was used with the Mideast Region to reduce the number of teacher variables to eight interpretable factors. These factors were used as variables in the development of a path analysis model relating science-teaching practices factors with other teacher-variable factors. The path analysis model developed for the Mideast Region suggests that the use of science teaching activities other than lecture-discussion, group laboratory activities, and science demonstrations and/or the use of selected audio-visual aids are influenced by the availability of funds for supplies and equipment only after the teachers have participated in science in-service activities.

This study is significant because it makes use of a relatively infrequently used analysis technique: path analysis. Follow-up studies with data from other regions can be used to test the models proposed as a result of this study. The results tend to show the importance of science in-service participation in influencing changes in science teaching. The path analysis model, proposed by the use of data from the Mideast Region, related a number of science-teaching variables by means of a few factors. Such a model gives indications that many variables taken together may influence science teaching practices only when other conditions are also present. In this case a budget for supplies and equipment appeared to influence the use of selected audio-visual aids and/or the use of alternatives to lecture-discussion, group-laboratory activities, and science demonstrations only when the teachers had participated in science in-service activities.

THE PREDICTION OF SUBJECT MATTER BIAS RELATED TO SCIENCE IN THE ELEMENTARY SCHOOLS

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Science educators have been concerned for some time about the apparent imbalance of emphasis between science and other disciplines in the elementary school. An effective science methods course should minimize any bias against teaching science. An instrument that provides an objective, reliable and valid estimate of subject area bias in elementary teachers is a necessity in evaluating the impact of any science education program. The purpose of this study is, therefore, to produce preliminary validation information for an instrument that measures the bias of elementary school teachers toward four disciplines: science, mathematics, social studies and language arts.

An inventory consisting of 36 items was presented to a sample (150) of elementary education majors. Each item on the instrument was designed to elicit biased responses between pairs of school disciplines (i.e. science-mathematics, science-language arts, science-social studies). Responses for each item were recorded on a five-point scale of bias between the discipline pair. A total score for each of the four disciplines was computed, providing a scale of bias for each S. Reliability of the total scores for each discipline was derived using a split-half technique. The validity of the instrument was estimated by correlating the bias scores of a sample of elementary school teachers with their indicated willingness to specialize in teaching each of the four subject areas.

Preliminary data suggest that the school subject inventory is a highly reliable instrument. Split-half reliability coefficients derived in the study ($>$ .90 for the four scales) indicated that scores of bias between the four major subject areas are uniformly consistent. Correlations between bias scores derived from the instrument and willingness to teach the subjects indicate that the instrument may be a useful tool in predicting bias of teachers toward teaching the four disciplines (validity measurements of .63 for math, .65 for language arts, .71 for science, and .80 for social studies).

PAPER SETS

Session A. Evaluation of Teacher Education in Science at the University of Iowa.

Presiding: William L. Sharp, University of Iowa, Iowa City, Iowa.

1. "Effectiveness of Science Teacher Education Program Prior to 1970." Leon Zalewski, University of Iowa, Iowa City, Iowa.
2. "The Iowa-UPSTEP Program: Evaluation of Program 1970-1972." Edward L. Pizzini, University of Iowa, Iowa City, Iowa.
3. "Iowa UPSTEP: Current Program Evaluation." John T. Wilson, University of Iowa, Iowa City, Iowa.
4. "The Projected Iowa-UPSTEP Model." William L. Sharp, University of Iowa, Iowa City, Iowa.

EFFECTIVENESS OF SCIENCE TEACHER EDUCATION PROGRAM PRIOR TO 1970

Leon Zalewski
University of Iowa
Iowa City, Iowa

The first phase of the teacher education program at the University of Iowa can be described as a conventional program. It was a typical program where the professional sequence began during the junior year and culminated during a single semester of the senior year. Prior to 1970, all senior science teaching majors enrolled in two secondary science courses: Biological and Physical Science Methods. The integrated Biological and Physical Science Methods Courses met daily for eight weeks. A sequential plan of study then required seniors to enroll in eight weeks of student teaching.

Students following this plan of study considered student teaching and methods to be the most worthwhile aspects of the old program. Over 70 percent of the teachers graduating from such a program classified the assistance provided during student teaching as valuable or extremely valuable. However, a significant number of graduates from the conventional program felt that more preparation and attention should be provided to future science teachers.

A later study concerning the practices and characteristics of Methods students provided some interesting baseline data. Changes were found to occur among Secondary Science Methods Students. The study indicated changes in self-concept, creativity and teaching philosophy. Methods students also tended to teach more like High Inquiry Teachers rather than Low Inquiry Teachers. These changes will be compared to results gathered after initiation of Iowa-UPSTEP.

THE IOWA-UPSTEP PROGRAM: EVALUATION OF PROGRAM 1970-72

Edward L. Pizzini
University of Iowa
Iowa City, Iowa

The purpose of this study was 1) to determine initial measures of self-concept, dogmatism, and science teaching philosophy of prospective science teachers enrolled in the Iowa UPSTEP I and II programs during 1971-72 academic year, 2) to determine changes in self-concept, dogmatism, and science teaching philosophy of prospective science teachers after participating in the Iowa UPSTEP I and II programs, and 3) to determine the effects of an early exploratory experience program on the development of attitudes toward teaching and selected concepts.

The instruments for this study included the following:

1) Tennessee Self-Concept Scale

2) Science Teaching Assessment Test

3) Rokeach Form and Dogmatism Scale

4) Minnesota Attitude Teacher Inventory

5) Semantic Differential for Selected Educational Concepts

The experimental design for this study consisted of one group pretest-posttest design for Iowa UPSTEP I and a pretest-posttest control group design for Iowa UPSTEP II. In addition, a one group pretest-posttest design was utilized to investigate the effects of early classroom experience. The statistics utilized consisted of the "t" for independent and related samples.

In general, the findings of this study suggested that the experimental Iowa UPSTEP program was effective in contributing to positive growth in self-concept, science teaching philosophy, and attitude toward educational concepts.

IOWA UPSTEP: CURRENT PROGRAM EVALUATION

John T. Wilson
University of Iowa
Iowa City, Iowa

In a formative evaluation effort to determine the impact of the Iowa UPSTEP science teacher education program, both written and performance measures were utilized. Written instruments included measures assessing the trainees' factual knowledge relative to various science curricula and content areas, their knowledge and capability to utilize concepts of instructional design, teaching skills, and characteristics of learners, and their perceptions of themselves as teachers as reflected by their attitudes, philosophy of education, and self-concept. Performance measures focused on the trainees' repertoires of teaching behaviors and skills in microteaching situations and also on a wide range of skills trainees acquired from their participation in clinical experiences, including tutoring, teaching children with special learning problems, and assisting classroom teachers in classroom management and planning.

Based upon the data collected, the Iowa UPSTEP program had a positive effect upon the trainees' perceptions of themselves as teachers. In addition, UPSTEP trainees' performance in microteaching situations were about equal to that of students from regular methods courses, in spite of the fact that Iowa UPSTEP program includes only seminars and clinical experience rather than formal methods courses. Other data collected were primarily descriptive but supportive of the UPSTEP program. A more rigorous and thorough evaluation of the UPSTEP program, now in progress, must be completed before notions of general support can become conclusions.

THE PROJECTED IOWA-UPSTEP MODEL

William L. Sharp
University of Iowa
Iowa City, Iowa

This presentation outlines a projected model for Iowa-UPSTEP based upon the research reports which precede it. Information is available concerning the standard program that consisted of a six hour foundation block during the last part of the junior year, a six hour methods block at the beginning of the senior year, and student teaching during the last part of the senior year. In 1970 Iowa-UPSTEP was begun as a formal project. It incorporated pre-college meetings and a seminar series during the freshman and sophomore years. During 1972-1974 several changes in the program occurred. The changes included field-centered activities, clinical experiences that included mastery of specific competencies, easy exit and entrance points, a lessening of the in-service/pre-service interface by the development of three week summer conferences which include in-service teachers. The program has resulted in a professional education sequence which is equally distributed throughout the four years.

Research information concerning the current program allows certain projections as to Iowa-UPSTEP beyond 1975. Characteristics of this projected program will be discussed. The primary features include the following:

1) Greater emphasis upon recruitment and activities in the secondary school.

2) Development of a resource of clinical experiences throughout the sophomore and junior years.

3) Disappearance of the usual course pattern for a teacher education program.

4) Expansion of the summer conference activities.

5) Greater attention to research information for future program development.

6) Observation and laboratory practice throughout the last two years of the four year program.

7) Increased activity with Iowa-UPSTEP graduates.

8) Broadening of the array of clinical experiences available.

PAPER SETS

Session B. Comparative Studies of Affective and Cognitive Learning Under Two Quantitatively Defined Teaching Strategies

Presiding: Alan M. Voelker, Northern Illinois University, DeKalb, Illinois.

Participants: Charles C. Matthews, Florida State University, Tallahassee, Florida.

James Shymansky, University of Iowa, Iowa City, Iowa.

Ronald Good, Florida State University, Tallahassee, Florida.

Patricia Kolebas, Florida State University, Tallahassee, Florida.

John Penick, Loyola University, Chicago, Illinois.

Jane Leonard, Florida State University, Tallahassee, Florida.

Everett Stallings, Winthrop College, Rock Hill, South Carolina.

Abu Hassanbin Ali, Education Ministry, Malaysia.

COMPARATIVE STUDIES OF AFFECTIVE AND COGNITIVE LEARNING UNDER TWO QUANTITATIVELY DEFINED TEACHING STRATEGIES: PARTS I AND II

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Education Ministry
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The need to establish more clearly relationships between various instructional strategies and student learning demands a systematic and deliberate control of instructional strategies in a laboratory environment and systematic monitoring of various aspects of student learning. Studies to be reported by participants in this symposium were conducted in such a laboratory environment. These studies grew out of the early studies of well known researchers such as Anderson and Flanders. They were conducted at the developmental research school of Florida State University beginning in the Fall of 1971 and continuing to the present time. Data which formed the basis for conclusions were collected during the 1971-72 and the 1972-73 academic years. Since the studies are continuing during the 1973-74 academic year, a preliminary examination of this third-year data is possible.

Various aspects of affective and cognitive learning and specific categories of student classroom behavior were studied under two quantitatively defined sets of learning conditions. Learning conditions were defined in terms of science materials, physical plant, and teacher behaviors. Contrasting learning conditions investigated in these studies were produced by varying teacher behaviors while holding the other two factors constant. The terms "teacher-structured learning in science" (TSLS) and "student-structured learning in science" (SSLS) refer to the two quantitatively defined patterns of teacher behavior. The major question pursued in these studies is: Is there a difference in classroom behaviors, student's self-perception, information acquisition, problem solving ability and confidence, verbal and figural creativity, and measures of cognitive developmental level between students under SSLS conditions and students under TSLS conditions?

Appropriate hypotheses associated with this question were generated and tested.

The effects of SSLS and TSLS teacher behaviors on the classroom behavior and learning of 250 students in grades 1-5 and 50 students in high school chemistry at the Florida State University Developmental Research School were investigated under the controlled conditions of twelve classrooms. Students at each grade level were randomly assigned to two sections prior to their enrollment in the fall of 1972. Both groups of students at each grade level were taught science by the same teachers using identical materials and classroom facilities. The learning conditions differed only in terms of teacher behaviors. SSLS and TSLS teacher behaviors were defined in terms of the following categories: (1) does not observe student, (2) observes but does not respond to student behavior, (3) accepts student behavior without evaluating, (4) praises or evaluates student behavior, (5) rejects and/or discourages student behavior, (6) reprimands student for behavior or uses unpleasant ridicule, criticism, or sarcasm, (7) asks questions which are intended to solicit information from students, (9) makes statement or asks question which directs the child regarding what to do and/or how to do an activity and (10) miscellaneous. The TSLS instructional strategy includes directive teacher behaviors and immediate feedback to the students on the acceptability of his response. SSLS teacher behaviors involve allowing students to invent their own activities and responding without directions to student behaviors. SSLS and TSLS teaching behaviors are defined quantitatively by a "learning conditions index," which was computed by comparing the number of teacher behaviors falling into categories 4, 5, and 9 to the total number of behaviors recorded. This fraction yields values from 0.0 (totally non-directive) to 1.0 (totally directive). The LCI for SSLS was kept below 0.05 while the LCI for TSLS was above 0.50. Each teacher in the study was trained to exhibit both patterns of behavior.

Classroom behaviors of students were studied by coding the behaviors of individual students in terms of the following categories: (1) observes student or teacher who demonstrates for the teacher, (2) follows teacher's directions as to what activities and/or how the activity should be done, (3) does activity of his own design; does not follow any specific teacher direction, (4) responds to teacher question or request by telling or showing, (5) initiates or attempts to initiate, interaction with the teacher; continues self-initiated interaction with the teacher, (6) initiates interaction with another student, (7) receives ideas from another student who is not demonstrating for the teacher, (8) copies other student, (9) gives idea to another student, and (10) miscellaneous.

In addition to classroom behavioral data, the following data were collected in pre- and post-tests as indicators of cognitive and affective learning:

1. Student self-perception in Science. Instruments developed in this project were used to assess the student's perception of himself with regard to science.

2. Creativity. Both forms of the "Torrence Test of Creativity" were used for selected students.

3. Problem solving. Techniques and instruments developed in this project were used. Individual interviews were conducted in order to assess ability and confidence in problem solving.

4. Cognitive developmental levels. Students were tested individually on classification, perimeter/area, and conservation of number, area, displacement volume, internal volume and perimeter.

5. Information acquisition. Data were taken from standardized science achievement tests.

Utilizing the data described above, appropriate hypotheses were tested by parametric and non-parametric statistical instruments.

The classroom behaviors and learning of students under SSLS differ from classroom behaviors and learning of students under TSLS. Changes in cognitive developmental level of students seem to be approximately the same for those taught by SSLS and those taught by TSLS.

PAPER SETS

Session C. The Measurement of Program Implementation and Students Cognitive, Affective, and Social Performance in a Field Test of the Inquiry Role Approach (1972-73)

Presiding: Daniel S. Sheldon, University of Iowa, Iowa City, Iowa.

Participants: Lowell A. Seymour, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

Richard M. Bingman, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

Paul G. Koutnik, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

Lawrence F. Padberg, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

Kenneth A. Burton, Mid-Continent Regional Educational Laboratory, Kansas City, Missouri.

THE MEASUREMENT OF PROGRAM IMPLEMENTATION AND STUDENTS' COGNITIVE, AFFECTIVE, AND SOCIAL PERFORMANCE IN A FIELD TEST OF THE INQUIRY ROLE APPROACH (1972-73)

Lowell A. Seymour
Richard M. Bingman
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Lawrence F. Padberg
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Mid-Continent Regional Educational Laboratory
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I. IMPLEMENTATION: ITS DOCUMENTATION AND RELATIONSHIP TO STUDENT INQUIRY DEVELOPMENT

Three aspects of program implementation were studied: 1) Can the Inquiry Role Approach (IRA) program be implemented? 2) Is there any significant relationship between type of training and degree of implementation? 3) Is there any significant relationship between degree of implementation and student outcomes in biology content knowledge, cognitive inquiry skills and affective inquiry qualities? Data for determining implementation were collected from fifteen teachers using a Teacher's Log and 1,300 students using the Views and Preferences-C and Class Activities Questionnaire. Criteria were established for implementation which resulted in three categories - very adequate, adequate, and inadequate implementation. Categories of training were defined and utilized in relating training to extent of implementation. The Comprehensive Final Examination, Explorations Final Examination, Explorations in Biology, and Biology Student Behavior Inventory instruments were used to measure student outcomes. Fourteen of the 15 teachers implemented the program adequately or very adequately. No significant relationship was found between the variables, type of training and degree of implementation. There were overall significant relationships between the variables, degree of implementation and student outcomes in the aforementioned areas. These correlations were low and accounted for little of the total variance.

II. DESCRIPTION OF STUDENT PREFERENCES FOR AND PERCEPTIONS OF SELECTED CLASSROOM CONDITIONS, TEACHER BEHAVIORS, AND CLASS PROCEDURES

Problem areas were: 1) What were the views and preferences of Inquiry Role Approach students? 2) Were there any significant relationships between selected views and preferences and selected views, views and/or preferences, and student outcomes? Data indicating student views and preferences were collected from students during the 1972-73 academic year via two instruments: Class Activities Questionnaire and Views and Preferences-Form C. Student outcomes were measured using Comprehensive Final Examination, Explorations in Biology, and Biology Student Behavior Inventory. A variety of relationships were indicated and some provide areas for future research.

III. STUDENT COGNITIVE, AFFECTIVE AND SOCIAL SKILLS PERFORMANCE

Problems were: 1) To determine whether there were significant increases, in classes where the program was at least adequately implemented, in biology content, cognitive inquiry skills, and affective qualities of inquiry; 2) To determine whether there were significant differences in student outcomes in biology content knowledge, cognitive inquiry skills, and affective inquiry qualities between students in the following sub-groups: a) Verbal and numerical ability at the 75th percentile or above, b) From the 50th to the 74th percentile, c) From the 25th to the 49th percentile, and d) at the 24th percentile and below; 3) To determine whether there were significant differences in student outcomes in biology content knowledge, cognitive inquiry skills, and affective inquiry qualities between IRA and non-IRA students. Secondary biology IRA teachers and students during the 1972-73 academic year were the source of the data collected via: 1) Comprehensive Final Examination, 2) Explorations in Biology, 3) Biology Student Behavior Inventory, and 4) Differential Aptitude Test instruments.

Significant development was shown by IRA students in cognitive inquiry and knowledge of biology content. The evidence for the development of affective qualities of inquiry is less definitive but tends to support the conclusion of significant development of these qualities. Differences were noted among the different ability subgroups on the cognitive variables, but this was not generally the case for the affective qualities of inquiry. IRA students demonstrated significantly higher development compared to non-IRA students in the areas of cognitive inquiry and affective qualities. Non-IRA students demonstrated significantly higher development in the area of biology content knowledge.

PAPER SETS

Session D. Evaluation of a "Parity" Model CBTE Program in Science Education

Presiding: Paul Joslin, Drake University, Des Moines, Iowa.

1. "CBTE Program in Science Education: Experimental Design." Douglas J. Harke, Patrick J. DeMarte, R. Wayne Mahood, State University College, Geneseo, New York.
2. "CBTE Program in Science Education: The Concerns Model and the Geneseo/STP CBTE Program." R. Wayne Mahood, Patrick J. DeMarte, Douglas J. Harke, State University College, Geneseo, New York.
3. CBTE Program in Science Education: Measurement of Variables." Patrick J. DeMarte, Douglas J. Harke, R. Wayne Mahood, State University College, Geneseo, New York.

CBTE PROGRAM IN SCIENCE EDUCATION: EXPERIMENTAL DESIGN

Douglas J. Harke
Patrick J. DeMarte
R. Wayne Mahood
State University College
Geneseo, New York

The goals and nature of a Competency-Based Teacher Education (CBTE) program requires both external and internal evaluation. The very nature of the competencies, to be attained by each student, dictates that criterion-referenced evaluation is the most suitable method. The literature of the 1960's contains numerous articles which attempt to compare courses, methods and programs. This research is often inconclusive because of confounded variables and inappropriate instruments. This experience also suggests that the evaluation of a CBTE program should be criterion-referenced.

The evaluation of a CBTE program should seek to answer the following questions:

1. Is the program valid with respect to the Concerns Model?

   The administration of a Self-Assessment Inventory to randomly-selected groups at various stages in the program might provide indications of both Concern focus and level.

2. Do the individual instructional components meet their stated criteria?

   This question might be answered by monitoring both intra and extra-module variables. Each module includes performances, instructional activities keyed to the performances and assessments to determine whether a performance has been met. Establishing validity of the assessments might be done by checking if teachers, who already have the competency being measured, can pass the assessment. Difficulty, for a student, in passing an assessment might reflect on the effectiveness of the related learning activity. Correlations of variables in a module with external variables such as total completion time and attitudinal ratings might provide information on the module's effectiveness in the total program.

3. Is the pre-assessment valid for admission and placement of students in the program?

   The validity of the components of the pre-assessment could be determined by a multiple regression procedure with the pre-assessment measurements as the independent variables and total completion time, unsuccessful or successful completion, student-rated difficulty, initial assessment success, and attitudinal ratings as possible dependent variables.

4. Are the program components arranged for optimum learning?

   Path and pattern correlations with success frequency and attitudinal ratings on individual assessments would provide feedback on sequencing the components.

5. How well does the total program prepare the student for a career in teaching?

   Preparation of a competent teacher can be holistically assessed by an integrated teaching activity at the conclusion of each major division in the program. Data from item # 1 would provide indications of the student's attitudinal readiness to become a teacher.

6. What is the place of parity (concensus of teachers, school administrators, students, public and college faculty) in a CBTE program?

   Surveys of the role expectations and fulfillments would attempt to detect attitudinal changes of teachers, school administrators, public, students, and college faculty towards teacher education.

CBTE PROGRAM IN SCIENCE EDUCATION

THE CONCERNS MODEL AND THE GENESEO/STP CBTE PROGRAM

R. Wayne Mahood
Patrick J. DeMarte
Douglas J. Harke
State University College
Geneseo, New York

The Science Trial Project (STP) is one of twelve competency-based certification projects funded by the New York State Education Department in October 1971. A complete description of this project is given in Harke and DeSeyn (1972).

The STP followed the process standards set forth in the *New Style of Certification*. These standards include the following: the formation of a decision-making process and a policy board. The STP Board is comprised of representatives of six agencies which include school boards, teacher bargaining units, teacher education students, collegiate faculty, Science Teachers Association of New York State, and a local scientific association. The voting parity of the six agencies reveals a low profile for the colleges in the decision-making process.

This joint board has succeeded in developing the following:

a) a master set of objectives for teaching science in the secondary school,
b) competencies for teaching science in the secondary school,
c) auto-instructional modules to assist teacher education students in meeting the competencies,
d) plan for implementation of the program,
e) a management system,
f) a design for evaluation.

Components (c) and (f) above were jointly developed with the Competency-Based Teacher Education (CBTE) project at SUNY Geneseo.

Simultaneously a competency-based teacher education program was developed at SUNY Geneseo. In this program the Fuller Concerns Model, which is described in *Personalized Education: An Introduction for Teacher Educators*, serves as one of the theoretical bases for the new Geneseo CBTE program.

The Concerns Model portrays the potential teacher as proceeding through three phases: Concerns about Self, Concerns about Self as a Teacher and Concerns about Pupils. These phases are reflected in the Geneseo CBTE program by the following sequence:

A. Pre-assessment - The student, when choosing a teacher certification track, will undergo a series of interviews and take a battery of tests including attitude and personality inventories, self-assessment inventories and an assessment of previously acquired teaching skills. Each student will be assigned to a support group which will remain intact throughout the program.

B. Core I - This includes instructional modules in Affective Education; Social, Cultural and Physical Setting of the Schools; Human Development; and Teaching. During this phase it is expected that the student will function on an aide level and that his/her Concerns should begin shifting from Self to Self as a Teacher.

C. Core II - Included are instructional modules in the same general areas as Core I but at a more advanced level. The student, at this level, should function as a participant and Concerns should center on Self as a Teacher.

D. Internship - The student teaching phase also includes additional modules on teaching and professional evaluation. Concerns of the student teacher should now begin to shift toward Concerns about Pupils.

The Geneseo CBTE program components were written jointly by college faculty, teachers, administrators and students. The secondary science education components and some of the core modules were developed in conjunction with the Science Trial Project.

CBTE PROGRAM IN SCIENCE EDUCATION: MEASUREMENT OF VARIABLES

Patrick J. DeMarte
Douglas J. Harke
R. Wayne Mahood
State University College
Geneseo, New York

There are an infinite number of variables in any teacher education program. Defining and categorizing the critical variables is the first step in the process of measuring the effectiveness of any such program. This paper will describe the design and means of assessment for the significant variables in the Geneseo-STP CBTE program.

The variables are categorized in terms of their relationship to process and/or the product of the CBTE program.

I. Product Centered Variables

(1) Pre-Assessment of Students

(a) Self-Assessment Inventory - to determine both the level and direction of student concerns; to be used for placement and counseling students into or out of the program.

(b) Teaching Level Assessment - to survey previously acquired teaching skills so that students can be placed in an appropriate starting point in the program.

(2) Integrated Skills Assessment

This is designed to determine students' progress and will assess attitudes, knowledge, and skills attained at major break-points in the program.

II. Process Centered Variables

(1) Module Assessment

(a) Student Evaluation Form - to provide the following quantitative information for each module: module quality, validity of each assessment, number of activities completed, and time required to complete the module.

(b) Instructor Evaluation Form - to provide the following quantitative information for each module: validity of the activities, validity of the assessment, validity of the performances, and a rating of overall effectiveness.

(2) Role Satisfaction

This would be accomplished by surveying role expectations and fulfillments of students, teachers, school administrators, college faculty, and others involved in the program. The instrument would attempt to detect attitudinal changes with regard to new roles involved in planning and operating a parity model CBTE program.

The data processing system to be developed for the Geneseo-STP CBTE program must store all pertinent academic information acquired as a student progresses through the program. Data access is another important factor in the design of the data processing system. Rapid profile-printouts of the students would be necessary for counseling and advisement purposes. Equally important is access to certain parts of the data so that frequency diagrams, correlations, and significance tests can be run to provide rapid feedback for formative assessments.

PAPER SETS

Session E. Information Theoretic Memory Model

Presiding: Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.

1. "Cultural Differences of Libyan and American Children in a Sorting and Piagetian Task." Abdulrazik Attashani and Roberto A. Pesenti, University of Pittsburgh, Pittsburgh, Pennsylvania.

2. "Relationships of Learning and Cognition in a Verbal and Visual Task." Chick O. Empfield, Fox Chapel Area School District, Pittsburgh, Pennsylvania.

3. "Relationships Between Memory Recall and Learning of Abstract Problem Solving and Piagetian Tasks." Michael F. Fezar, Allegheny County Community College, Pittsburgh, Pennsylvania.

4. "Characteristics of Primacy and Recency Processing of a Learning and Cognition Task." David L. Dunlop, Fox Chapel Area School District, Pittsburgh, Pennsylvania.

5. "Relationships of Concrete Learning and Concrete and Abstract Cognitions." Bonnie L. Dean, University of Pittsburgh, Pittsburgh, Pennsylvania.

6. "Relationship of Personality Characteristics and an Abstract Problem Solving Task." Mary E. Sweeney, University of Pittsburgh, Pittsburgh, Pennsylvania.

7. "Relationships of the Intellect with the Processing of a Learning and Cognition Task." Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.

8. "A Visual Demonstration of Children in Learning and Cognition Tasks." Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania and Chick O. Empfield, Fox Chapel Area School District, Pittsburgh, Pennsylvania.

CULTURAL DIFFERENCES OF LIBYAN AND AMERICAN CHILDREN IN A SORTING AND PIAGETIAN TASK

Abdulrazik Attashani

and

Roberto A. Pesenti
University of Pittsburgh
Pittsburgh, Pennsylvania

The performance of Libyan and American children on two tasks was studied to determine cultural differences in memory information processing. Fifty-four 16 year old children of each national origin were randomly selected for the study. Two task treatments were made and analyzed for information flow. One was a replication of the Inhelder and Piaget task of combining colored and colorless chemical bodies. The other task was the practice sorting of 14 geometric figures and the immediate recall of the location of the figures and their properties of shape, color and identity number.

The children of both cultures treated both tasks as being of problem solving modes, with the chemical bottles task involving a greater amount of probabilistic reasoning. Children classified as being of formal operational levels treated the chemical bodies problem differently than did those children of lower operation levels. The differences were of redundancy actions and spurious procedures. The performance data of subjects in the sorting task was found to be more discriminating for cultural differences than the behaviors in doing the chemical bodies task. The American subjects processed more set formations, utilizing more short term memory information in more spurious channels. The Libyan subjects used larger amounts of steady state useful information and relied on encoder actions in processing the task. Libyan subjects recalled fewer items than the American subjects. The recency procedure of recalling figure items by the subjects was found to reflect the learning differences of the two cultures.

The Libyan male task behavior and information processing characteristics were more different from those of American males than were found for female subjects. Libyan females processed the sorting task by using relatively nonspurious channels of information flow. This resulted in a more efficient cognition by the Libyan female subjects.

A dimension perception model of useful information retrieval for sorting task cognition was used to classify the M unit structure sorting task actions. Linear analyses of the M unit structure and operation levels for the chemical bottles task were found to identify cultural and sex differences in information flow pathways.

The major conclusion was that the information memory flow of 16 year old children have attributable cultural differences, when compared to Piagetian task performance and memory cognitions. This is the first report of a cultural study of information memory processing by humans in learning and recall tasks.

RELATIONSHIPS OF LEARNING AND COGNITION IN A VERBAL AND VISUAL TASK

Chick O. Empfield
Fox Chapel Area School District
Pittsburgh, Pennsylvania

The purpose of this study was to determine the amount and kind of visual information processed and stored in the memory of children using different modalities of observation. The task was a silent or vocal viewing of a projected 35 mm slide of a living room. The subjects then verbally recalled the viewing experience and later visually located a random selection of 20 outline cut-outs of living room picture items. Two hundred and sixty-one randomly selected children, aged five, nine and thirteen years, spent five minutes in each of the experiment phases.

Groups of three children enumerated more items than was done by the individual verbal viewers. However, the modality of picture viewing did not significantly affect the efficiency of recalling the picture content. The major factor was found to be that the amount and variety of recall increased as there was an increase in the age of the subjects. The same trend was observed for the non-verbal spatial location of picture objects.

The individual and group viewers of the picture produced different patterns of information processing in the learning experience. The amount of useful information processed was found to increase as there was an increase in the age of the subjects. Linear regression analyses of the information processed in the learning and recall experiments showed distinct relationships between task modalities and ages of the children.

A message processor algorithm for forecasting cognitions of verbal and nonverbal modalities was used with a prediction error of less than two percent. An item dimension algorithm for forecasting cognitions was developed to measure the M unit structure of memory pathways. The finding was that chronological age was related to M units of variations of learning and recall tasks.

The data of this study represent the first demonstration of the information theoretic model in analyzing age differences in modalities for processing visual information through the human memory.

RELATIONSHIPS BETWEEN MEMORY RECALL AND LEARNING OF ABSTRACT PROBLEM SOLVING AND PIAGETIAN TASKS

Michael F. Fezar
Allegheny County Community College
Pittsburgh, Pennsylvania

The problem of the study was to determine information memory processing relationships between memory recall and problem solving learning and cognition tasks done by subjects of different performance levels of Piagetian tasks. Two groups of 12 adult subjects were given different instruction on abstract reasoning. An abstract reasoning test was administered before and after the instruction. The subjects wrote a recall passage of the instruction. They then did a series of Piagetian tasks and a sorting task with an immediate recall of the displayed positions of figures and the properties of shape, color, and identity number.

There were no significant differences between pre and post instruction abstract reasoning levels for the two treatment groups. The group receiving logic instruction processed smaller amounts of encoder and useful information in the recall task. The group receiving abstract reasoning test instruction processed significantly greater amounts of spurious information. The information level of processing the sorting task was different, with the greater amounts of useful information occurring for the group which received instruction on abstract reasoning tests. There was no significant difference in the ability of the groups to recall the sorting tasks.

The relationships of performance in the Piagetian tasks and information flow in the memory recall and problem solving learning task showed the two groups had different patterns of useful and encoder processing. The logic instruction group utilized encoder linear relationships for the instruction recall and sorting task with performance in Piagetian tasks. On the other hand, the abstract reasoning instruction group used encoder and steady state useful information elements in a linear relationship between the two tasks and the level of cognition in the sorting task. The Moser dimension algorithm for predicting memory cognition levels was used for determining relationships of cognition to Piagetian task performance. The M unit of structure of the model was found to be significantly correlated with the recall of shape, color and number properties for the abstract reasoning group and with shape and color for the logic group of subjects. The M units for the cognition of the sorting tasks by the two groups were found to be linearly related with Piagetian tasks involving three variables and correlation operations.

Adult humans process memory recall and problem solving tasks differently depending upon levels of performance in Piagetian tasks and kinds of instruction in abstract reasoning. The differences are probably due to the amount of encoder and useful information processed by subjects, in terms of the kinds of environment dimensions and M unit levels of instruction.

CHARACTERISTICS OF PRIMACY AND RECENCY PROCESSING OF A LEARNING AND COGNITION TASK

David L. Dunlop
Fox Chapel Area School District
Pittsburgh, Pennsylvania

The purpose of this study was to use information theory to investigate the concepts of primacy and recency as they were exhibited by ninth grade science students while processing a biological sorting problem and an immediate, abstract recall task.

Two hundred randomly selected ninth grade science students were given a biologically orientated classification sorting problem. The problem required the students to observe, for fifteen minutes, a color slide composed of fourteen different animals. During this time the students were to group the organisms into sets. Then each student was given three minutes to recall, by means of a sketch, the visual display. By analyzing the order of recall in conjunction with the set formation list, a primacy and a recency score was determined for each student. On the basis of these scores the students were separated into the following groups: low primacy, high primacy, low recency, and high recency. These groups were examined with respect to their achievement on standard tests, cognition scores, set formation scores, and information values which were derived from the set formation elements.

When making a general comparison between high and low primacy as well as between high and low recency groups of students, t-test results showed that there was no significant difference in their general intellectual ability. In addition, there were generally no significant differences between the low and high groups (primacy and recency) with respect to their set formation scores. T-test results indicated significant (.05 or greater) differences in all recall categories between the low and high groups. Further, it was demonstrated that total cognition scores were slightly greater for the recency students when compared to the corresponding ability group for primacy. This suggested a slight, but not significant, advantage in total recall belonged to the recency groups. Linear analysis of eleven information measures indicated that the low and high primacy groups did not differ in the quantitative aspects of information processing. However, a study of product moment correlations derived from relationships between memory levels and set formation and cognition scores indicated that the actual processing for the two groups was somewhat different. The high primacy group tended to use the short-term memory to a greater extent than did the low primacy group. Similar statements may be made for the low and high recency groups. It was concluded that both the high primacy and the high recency groups of ninth grade students make more efficient use of the short-term memory store than do the low primacy and low recency groups.

RELATIONSHIPS OF CONCRETE LEARNING AND CONCRETE AND ABSTRACT COGNITIONS

Bonnie L. Dean
University of Pittsburgh
Pittsburgh, Pennsylvania

The problem was to test three algorithms for predicting cognition levels of six year old children in a series of five sorting task recall experiments. The algorithms were developed for interpreting useful information processed in two concrete learning tasks. Thirty first-grade children were randomly selected and individually given two concrete learning tasks of sorting 14 geometric figures. The subjects then did a concrete recall task of spatially locating the objects of the original experiment. Finally they conducted an abstract recall task which was followed by a 36 hour delayed abstract task. The sequence, with the exception of the delayed abstract recall task was then repeated.

The scores obtained in the series of recall tasks were found to be linearly related, with less dependence occurring between than within the kinds of recall modality used for recall. The amounts of useful information processed in the learning tasks were found to be related to each other as well as to subsequent recall scores, irrespective of recall modality. These findings enabled the development of three algorithms for forecasting individual levels of cognition. Two algorithms involved the amount of useful information and messages processed in the learning task. The first algorithm expressed the retrieval of useful information for cognition and had average recall prediction errors of five to sixteen percent. The second algorithm involved a series of six encode, storage, and processing for retrieval equations. The prediction of the five different recall scores had average prediction errors of less than one to seven percent.

The third kind of algorithm assumed the subjects perceived the learning task dimensions and encoder-processed useful information during cognition. An analysis was done for determining M units of structure of useful information of six year old subjects in each of the five recall tasks. The evidence of the analysis is that the M unit structure increased by M increments in repeated learning experiences and it is probably of a Piagetian relationship. A comparison of the data with that of 16 year old children indicated that the M unit increment for repeated learning may be a function of the basic M unit.

RELATIONSHIPS OF PERSONALITY CHARACTERISTICS AND AN ABSTRACT PROBLEM SOLVING TASK

Mary E. Sweeney
University of Pittsburgh
Pittsburgh, Pennsylvania

The purpose of this study was to establish the possible relationships of personality characteristics with the processing of information by humans in an abstract problem solving task. Thirty senior high school students were selected to do a problem of adjudicating the incestuous relationships of seven Greek-named parties. The subjects verbalized the five minute solution and the monologues were noun, pronoun term analyzed. The subjects also completed the Edwards Personal Preference Schedule (EPPS).

Two personality characteristic forecast algorithms were developed to test relationships with information measures. The first algorithm was based on the variety, messages, and useful encoder information processed by the subjects in solving the abstract problem. The algorithm equations were derived by establishing linear relationships between task components and personality characteristics.

The second algorithm involved isolating M units of information structure for personality characteristics evoked in processing the abstract task. Nine characteristics of individual subjects were forecast with prediction error averages of less than nine percent. Memory levels of information processing were found to categorize the forecast of personality characteristics. The steady state condition encoder was involved in predicting the intraception, affilitation, and change characteristics. The original condition information processing components were used to forecast the characteristics of succorance, abasement, nurturance, endurance, order, and aggression. The change, order, and aggression characteristics did not directly utilize M units of information structure in the equation for forecasting.

The processing of an abstract problem task has an information flow which is directly related to the EPPS characteristics of humans doing the task. These characteristics can be predicted from the useful information and memory processes of the task behaviors. This is the first report of the role of the human personality in memory information processing and retrieval.

RELATIONSHIPS OF THE INTELLECT WITH THE PROCESSING OF A LEARNING AND COGNITION TASK

Gene W. Moser
University of Pittsburgh
Pittsburgh, Pennsylvania

This study was done to test an information memory model for identifying the unit of information structure involved in task cognitions by humans. Four groups of 30 randomly selected subjects, aged 7, 9, 11, and 15 years did a sorting task of 14 geometric figures. Then they recalled the properties of color, shape and identity numbers of figures in spatial locations, corresponding to the display of figures in the passive learning session. Information theoretic measures were calculated from the messages of the set formations in the learning session.

Two algorithms were developed, with one adhering to the C. Shannon theorem of information being processed per observed message. This multiple step equation series involved encoder, processor, and cognition retrieval components for predicting the sorting task recall scores. The second algorithm assumed that humans perceived 42 dimensions in the sorting task and the equation components were then set for an encoding and retrieval operation, with an M unit structure of 0.155 bit of useful information. Increments of M unit structures were established on a base of 0.0129 bit of useful information. Individual recall scores were tested for the accuracy of forecastability. The respective average prediction errors were 4.17, 1.28, 3.03, and 3.33 percent by using the first message-encoder algorithm. The dimension algorithm predicted recall scores for an average of less than one percent error for all groups of subjects. The respective M increment adjustments necessary to obtain dimension algorithm predictions of less than one percent error were +.43, -0.20, +2.40, and +3.13.

The intelligence quotients of groups of subjects were then analyzed for their relationship with the information unit structure. The relationship found for obtaining prediction errors of less than six percent was that intelligence quotient is operated as a base two logarithm, and which is then a function of the M unit structure. The encoder component is a comparator which maximizes a retrieval of useful information. The comparison operation is the degree of reduction of uncertainty between independent and unknown messages to the match of known information with the former uncertainty.

The major conclusion of this study was that the human memory operates logarithmically with basic information units of structure at a level of 0.155 bit. The intellect level of a human is a function of increments, which shift with chronological age, and are adjusted by an information encoder which is related to the level of the human's processing of the learning environment.

AN HOUR WITH --- (A Chance for Communication)

Session A. The Editor and Editorial Board

Presiding: O. Roger Anderson

Session B. The President and President-Elect

Presiding: Wayne Welch

Session C. The Research Coordinator

Presiding: Stanley L. Helgeson

Session D. The Secretary-Treasurer, Newsletter Editors, Business Office

Presiding: Paul E. Bell

Session E. The 1975 Program Committee

Presiding: Robert Yager

Session F. Placement Coordinator

Presiding: Marvin Druger

Session G. National Institute of Education Programs

Presiding: George Gustafson

PANEL DISCUSSIONS

Panel A. Preparation of Research Summaries and Abstracts

Presiding: Richard L. Sagness, University of South Dakota, Vermillion, South Dakota.

1. "Technical Writing - - Common Problems as Viewed From the Receiving End." Richard L. Sagness, University of South Dakota, Vermillion, South Dakota.
2. "Suggestions for Improving Research Reports." Stanley L. Helgeson, The Ohio State University, Columbus, Ohio.
3. "Manuscript Preparation." O. Roger Anderson, Teachers College, Columbia University, New York, New York.
4. "Characteristics of Good Manuscripts." N. Eldred Bingham, University of Florida, Gainesville, Florida.

Discussant: James J. Gallagher, Governors State College, Park Forest South, Illinois.

TECHNICAL WRITING -- COMMON PROBLEMS
AS VIEWED FROM THE RECEIVING END

Richard L. Sagness
The University of South Dakota
Vermillion, South Dakota

The NARST Program Committee each year is faced with the difficult task of determining which proposals will be accepted in the development of the program for the annual meeting. The individuals submitting the proposals are faced with the equally difficult task of describing their paper, synopsis, etc. in a limited number of words. Another very directly related problem is the preparation of the abstract or synopsis which is required for publication in JRST.

As individuals who are on the receiving end of materials submitted from the membership, the panel will discuss the common problems encountered in reviewing and evaluating these materials and recommend solutions as well as solicit ideas from those in attendance. An anticipated outcome is a brief publication which will provide better guidance to the membership in the preparation of abstracts and summaries which are submitted to the NARST Program Committee or JRST reviewers.

SUGGESTIONS FOR IMPROVING RESEARCH REPORTS

Stanley L. Helgeson
The Ohio State University
Columbus, Ohio

The preparation of research reports for consideration by the NARST Program Committee, for inclusion in the compilation of abstracts, and for review for input to the ERIC system involves the need to present sufficient information about an often complex study in a brief and concise manner so that the reviewers can make informed decisions regarding acceptance of the report.

The report should contain a clear and explicit statement of the problem studied; a description of the population sample, sample size, and sampling technique; the experimental or treatment methodology employed; any instruments used; statistical analyses of data; and the results of the study. Statements of results or findings should be consistent with the problem statement. This does not exclude reporting findings not anticipated, but does require that the relationship of results to the problem investigated be maintained. Inclusion of inferences, implications, conclusions and recommendations is desirable but care should be taken that these are identified as such.

As a general rule, the report should be written in the past tense, which clearly implies that the research be completed prior to the submission of the report. When a reviewer is unable to determine from the report whether or not the study has been completed, the decision is usually to reject the report. While grammatical errors alone are rarely the basis for rejection, more care in editing the report does much to increase its chances for acceptance. A more serious problem is the acceptance, in the report, of a null hypothesis. Although this may be simply an error in a manner of writing, it raises the question of whether or not the researcher understands the nature of the hypothesis, which in turn creates doubts about the accuracy of the entire report.

MANUSCRIPT PREPARATION

O. Roger Anderson
Teachers College, Columbia University
New York, New York

The following is a statement about preparation of manuscripts from the standpoint of the editor and review board. Rather than setting forth those characteristics that are least desirable, those qualities of manuscripts that are particularly desirable will be cited.

The title of the manuscript should be as concise as possible, but clearly present the main ideas to be transmitted in the paper. The introductory section of the manuscript should do more than list prior research reported in the field. In addition to a literature review, the introduction should also set a clear rationale for the paper, stating the conceptual bases for the paper and explaining the theoretical relationships among the variables. Or, if the paper is non-experimental, the conceptual bases for pursuing the research should be made clear. The reasons for choosing various variables or situations to be examined should be carefully stated.

A concise section on methods should be included. Sufficient detail should be presented to allow replication of the research. New methods must be described in detail, whereas previously published methods can be cited by source and if necessary brief descriptions provided.

The results section is ideally a thorough statement of findings containing pertinent interpretations of the data necessary for a clear understanding. Discussions of data belong in the discussion section proper. A good discussion provides an interpretation of results in relation to the theoretical or conceptual statement presented in the introduction. When possible, relationships to prior research and new insights gained through the research pursued, as presented in the paper, should be set forth.

A bibliography containing full citation of sources is not only a mark of scholarliness, but also provides a useful aid to the reader in pursuing research in related fields.

CHARACTERISTICS OF GOOD MANUSCRIPTS

N. Eldred Bingham
University of Florida
Gainesville, Florida

For publication in a national journal a research paper should represent more than an account of a unique teaching experience or an interesting study which may or may not be applicable beyond the local situation. Pilot studies may be appropriate where characteristics and background of the subjects involved are presented, and where the findings are related to other studies reported in the literature.

It is desirable, however, that the findings of any study can be widely generalized. This is possible if care is used in designing the study with generalizability in mind. Populations studied should be representative of other populations and be characterized adequately. Experimental and control groups should be selected by random means. Situations selected for study should be representative of other identifiable situations with enough cases to yield significant differences.

Any factors that may modify the variability found should be discussed; appropriate statistical procedures with numbers, means, probability, and significance should be reported. Findings should be discussed in relation to their theoretical or philosophical implications, and in relation to other studies reported in the literature.

Papers may be concerned primarily with the theoretical or with the practical aspects of science education. It is well to present the philosophical, psychological, historical or research background for positions presented and to discuss arguments in the light of this background.

Papers should be as concise and clear as possible. Wordiness, redundancy, and the use of unexplained sophisticated technology should be avoided to improve readability.

Following are suggestions for format:

1. Title should be in caps and lower case, followed by name of author with business address.

2. Manuscript should be typed with duplicate copy, with margins of about 1 1/4 inches, with footnotes numbered consecutively with position of tables and figures indicated and with bibliographic references (preferably with last name of author and number in parenthesis).

3. Tables should be numbered consecutively, with title, appropriate headings and footnotes. Number of cases, means, standard deviations, and significance should be indicated. Each table should be on a separate sheet.

4. Figures should be numbered consecutively, drawn in India ink on separate sheet. Legends should be concise and clear.

5. The bibliography should furnish complete data on each item. Preferable arrangement is with each item numbered but arranged alphabetically according to author's last name. For books, include author, title, city, publisher, date of publication, and pages referenced. For magazine articles, include author, title, name of magazine, volume, number, date, and pages referenced.

PANEL DISCUSSIONS

Panel B. Various Paradigms in Science Education Research

Presiding: John F. Schaff, University of Toledo, Toledo, Ohio.

1. "The Fallacy of a Million Dollar Analysis of 99¢ of Data or Garbage In - Garbage Out." John W. Wick, Northwestern University, Evanston, Illinois.
2. "On Great Experiments In Science Education." Jack Easley, University of Illinois, Urbana, Illinois.
3. "What Is A "Research Problem?" James Raths, University of Illinois, Urbana, Illinois.

THE FALLACY OF A MILLION DOLLAR ANALYSIS OF 99¢ OF DATA OR GARBAGE IN - GARBAGE OUT

John W. Wick
Northwestern University
Evanston, Illinois

Although universities teach one set of courses called "research" and a second set called "testing or measurement" the two topics are closely entwined. Most research designs demand criterion scores -- scores which reflect "more of" and "less of" measures on the subjects involved. A variety of measurement scales are commonly used by science educators and many of these are homemade. These will be discussed, as will certain research ramifications of poor measurement design.

ON GREAT EXPERIMENTS IN SCIENCE EDUCATION

Jack Easley
University of Illinois
Urbana, Illinois

I've been thinking for several years about the strange lack of resemblance between the typical Ph.D. dissertation in education (especially science education) and the great, famous, scientific experiments which we teach in elementary science courses: Gallileo, Newton, Faraday, Harvey, Lavoisier, Mendel, von Helmont --at least as I understand what these men did. I suspect a growing tendency, only slightly reversed in the recent decade of curriculum reform, to cast all of these paradigmatic experiments in a more conventional form of dependent and independent variables and even with chi-square. In short, my thesis is that what made great experiments great is increasingly disguised in science teaching by new fashions in research design and is completely out of reach if we follow these fashions in our struggle to get a new science going--the science of the development of human understanding in school situations and subjects. My hypothesis is that newer research designs are a handicap and would never have permitted the great developments in physics, chemistry, and biology. That they are increasingly used (but still somewhat minimally) in these sciences, is no evidence at all that they could have gotten them "off the ground." Getting human knowledge of a new area off the ground is, as, Kuhn has pointed out, a very different business than either refining the current paradigm or trying to make sense out of the anomalies that give rise to a state of crisis.

Development of my thesis entails that, before we can hope to design great experiments in science teaching, we must understand the cognitive and social mechanisms which underlie the interactions between pupils, teachers, and objects of study. I will try to communicate this approach to my thesis by explicit, positive suggestions, but the deeply implied criticism of the contemporary research design paradigm may be left largely in this form: "Isn't it lucky that Faraday didn't know about chi-square?"

WHAT IS A "RESEARCH PROBLEM?"

James Raths
University of Illinois
Urbana, Illinois

This presentation will attempt to suggest one way for initiating inquiry in science education. Cohen and Nagel argue that no inquiry can get under way unless some difficulty is felt in practical or theoretical situations. Many times, the difficulty is found in attempts to account for observed variance. Some characteristics of significant problems will be discussed.

PANEL DISCUSSIONS

Panel C. Perspectives on Advance Degree Programs in Science Education

Presiding: David P. Butts, University of Texas at Austin, Austin, Texas.

1. "The Ph.D. for Preparation of Researchers." Joseph D. Novak, Cornell University, Ithaca, New York.
2. "A View of the Doctor of Arts Degree." Darrell B. Hoff, University of Northern Iowa, Cedar Falls, Iowa.
3. "Research in Communicating Knowledge -- The UICC Doctor of Arts Degree." Joseph I. Lipson, University of Illinois, Chicago, Illinois.

THE PH.D. FOR PREPARATION OF RESEARCHERS

Joseph D. Novak
Cornell University
Ithaca, New York

The primary goal for any doctoral program should be the preparation of researchers in that field. To utilize the Ph.D. in science education for preparation for a wider array of professional pursuits is a major issue in science education today. The number of institutions offering the doctorate should be few and should represent real centers of excellence. The preparation of college science teachers should not be a responsibility of the professional science educator.

A VIEW OF THE DOCTOR OF ARTS DEGREE

Darrell B. Hoff
University of Northern Iowa
Cedar Falls, Iowa

The two major functions of the university are: (1) the acquisition of new knowledge, and (2) the dissemination of all knowledge. People who accept positions of responsibility in higher education should accept the responsibility for promoting both functions. It is sincerely felt by this author that the effective dissemination of knowledge is enhanced by having experienced the acquisition of new knowledge. It is further contended that a person completing a Doctor of Arts degree (who has not completed a serious research project), but occupying a science education position will fail to convey the excitement of research, the diligence and patience required to do research and the benefits to be accrued both to the individual and to society from having done the research.

RESEARCH IN COMMUNICATING KNOWLEDGE --

THE UICC DOCTOR OF ARTS DEGREE

Joseph I. Lipson
University of Illinois
Chicago, Illinois

The University of Illinois at Chicago Circle has developed a Doctor of Arts program in response to a perceived need for a new point in the spectrum of talent in the field of science instruction. The D.A. will be educated to carry out research in communicating knowledge from a strong foundation of knowledge in a discipline in the elements of the instructional process; they will have been introduced to knowledge of the social and behavioral sciences which underlie the communication and learning process. Most important, they will have been taught the elements of research in science teaching.

In relation to the Ph.D., they will be somewhat less specialized and have a core of preparation in education, educational technology, and research techniques for social experiments. In relation to the Ed.D. or Ph.D. in Education, they will have more disciplinary preparation than is usually the case, but they will have less preparation in the philosophy of education, the history of education, the broad foundations of educational theory. The D.A. can be thought of as an intermediate member of the educational team.

The D.A., then, is intended to be a bridge between the disciplinary Ph.D. and individuals with other forms of preparation for careers in education. The program is experimental in nature. A reasonable, yet demanding, evaluation plan has been formulated and will be available for discussion.

PANEL DISCUSSIONS

Panel D. The Preparation of Graduate Students for Careers in Research

Presiding: John T. Wilson, University of Iowa, Iowa City, Iowa.

Participants: Lynn W. Glass, Iowa State University, Ames, Iowa.

Daniel J. Zaffarano, Iowa State University, Ames, Iowa.

David H. Ost, California State College, Bakersfield, California.

Alan M. Voelker, Northern Illinois University, DeKalb, Illinois.

THE PREPARATION OF GRADUATE STUDENTS FOR CAREERS IN RESEARCH

Lynn W. Glass
Iowa State University
Ames, Iowa

The future of science education as a viable area of knowledge rests squarely on the shoulders of researchers who are capable of utilizing experimental multivariate-longitudinal designs, designing and conducting basic research on topics such as the cognitive development of science-relevant concepts in young children, and developing centers of research in which groups of investigators coordinate their efforts in joint attacks on common problems (Shulman and Tamir, 1973).

This symposium has been designed to develop, to present, and to react to one model for the preparation of graduate students for careers such as those listed above in science education research.

A model for the preparation of graduate students for careers in research will be presented and analyzed. This model will be content-free in that it will be a model applicable for the sciences as well as the humanities.

GENERAL SESSION II

Presiding: Robert E. Yager, University of Iowa, Iowa City, Iowa.

Speaker: Lee S. Shulman, Michigan State University, East Lansing, Michigan.

"The Psychology of School Subjects: A Premature Obituary?"

PAPER SETS

Session A. Aptitude Treatment Interaction in Science Education

Presiding: J. David Lockard, University of Maryland, College Park, Maryland.

1. "A Rationale for Investigating Differential Responses of Learners to Instructional Treatments in Science Classrooms." John T. Wilson, University of Iowa, Iowa City, Iowa.

2. "Some Basic Statistical Procedures for ATI Studies in Science Education." Kenneth Loose, University of Florida, Gainesville, Florida.

3. "Aptitude x Treatment Interaction Studies in Science." John J. Koran, Jr., University of Florida, Gainesville, Florida.

4. "Differential Effectiveness of Two Science Diagrams Types." William G. Holliday, Lawrence L. Brunner, and Edward L. Donais, University of Calgary, Calgary, Alberta, Canada.

A RATIONALE FOR INVESTIGATING DIFFERENTIAL RESPONSES OF LEARNERS TO INSTRUCTIONAL TREATMENTS IN SCIENCE CLASSROOMS

John T. Wilson
University of Iowa
Iowa City, Iowa

A common strategy in science education has been to seek the one best method of instruction for any given group of learners. However, learners differ; the search should be for multiple ways in which instruction can be varied as to fit the characteristics of learners. A theoretical framework, commonly called Aptitude x Treatment Interaction (ATI), provides a means for relating instructional variables to learner characteristics. According to this framework, an interaction between learner aptitude and instructional treatment condition is present when one instructional treatment is significantly better for one type of learner while an alternate treatment is significantly better for a different type of learner. Here, aptitude is defined as any characteristic of the individual which functions selectively with respect to learning. The kinds of aptitudes and processes required by various learning tasks are identified through theoretical analysis and research. Conditions assessed as necessary for learning the task may then be either adapted to identified individual differences or perhaps the individual can be taught how to engage more effectively in these processes.

SOME BASIC STATISTICAL PROCEDURES FOR ATI STUDIES IN SCIENCE EDUCATION

Kenneth Loose
University of Florida
Gainesville, Florida

The purpose of this paper is to present some of the basic procedures which would enable experimenters to engage in the analysis of aptitude x treatment interaction studies in science education. Beginning with an examination of the correlation matrix of dependent and independent (or predictor and criterion) variables by treatment, indicators of possible significant combinations of predictors and criteria can be established, and are noted. The simple theoretical basis of the statistical procedures utilized, along with an example, form the major portion of the paper. These are used to illustrate how various types of aptitude x treatment interactions can be determined, as well as F-tests for significance of the interactions. Throughout this part of the discussion, interactions using a single predictor as well as statistics which do not involve matrix manipulation are dealt with in order to facilitate explanation. However, the remainder of the discussion attempts to consider analysis using multivariate or more than one predictor. Elaboration of technique used to adapt readily available programs such as BMD to aptitude x treatment interaction research, as well as a short discussion of advantages and shortcomings of these "canned" programs completes the discussion.

APTITUDE X TREATMENT INTERACTION
STUDIES IN SCIENCE

John J. Koran, Jr.
University of Florida
Gainesville, Florida

Aptitude X treatment interaction research is an attempt to explore those treatments that are most suitable for individuals with particular characteristics. In those studies subjects are tested on various cognitive and affective measures and then exposed to a number of treatments. Criterion performance can be measured by either live verbal or nonverbal behavior, or by a paper and pencil test. Multiple regression analysis of aptitude by treatment interactions is conducted to determine for what subjects under what conditions learning is facilitated. The results of studies of this type may eventually contribute to an alternative to self-paced instruction as a means of adapting instruction to individual differences.

The results of a number of studies will be reviewed here to show the relationship between such aptitudes as verbal fluency, inductive reasoning, and general ability to learning science material from different modes of instruction.

DIFFERENTIAL EFFECTIVENESS OF TWO SCIENCE DIAGRAM TYPES

William G. Holliday
Lawrence L. Brunner
Edward L. Donais
University of Calgary
Calgary, Alberta, Canada

Aptitude Treatment Instruction (ATI) theory and research indicate that different effective instructional treatments tend to help some kinds of learners more than others. These findings have cost, facility and personal implications for the design and implementations of science curriculums and the development of individualized instructional programs. Eighty-two high school science subjects were randomly assigned to a word or word-picture diagram (i.e., pathway or cyclic schema with adjunct questions) treatment. Multiple regression analysis of posttest scores (predictors: verbal ability and pretest scores) supported the _a priori_ hypothesis that low verbal subjects seemed to benefit from certain verbal and pictorial referents. Higher verbal ability subjects appeared to be less dependent upon the investigated pictorial referent type in terms of the verbal (non-pictorial) criterion test.

PAPER SETS

Session B. University of Delaware Research in Science Education

Presiding: Carleton W. Knight, University of Delaware, Newark, Delaware.

1. "Teacher Acceptance of Performanced Based Objectives." Robert L. Uffelman, University of Delaware, Newark, Delaware.

2. "Designing a Model for Developing Learning Materials that Provide Elementary Teachers with Content Background in Science in an In-Service Workshop Format." Winston Cleland, University of Delaware, Newark, Delaware.

3. "Evaluating the Preparation of Classroom Observers Through Audio-Tutorial Video Tape Units." Sally G. Kehoe, University of Delaware, Newark, Delaware, and Carleton W. Knight, University of Delaware, Newark, Delaware.

4. "A Comparison of Retention Levels Resulting from the Traditional and Modular Laboratory Approaches." Carleton W. Knight, University of Delaware, Newark, Delaware, and Gary E. Dunkleberger, Alexis I. duPont High School, Greenville, Delaware.

TEACHER ACCEPTANCE OF PERFORMANCE-BASED OBJECTIVES

Robert L. Uffelman
University of Delaware
Newark, Delaware

The objectives of this study were to determine what teachers feel are (1) the relevant teaching competencies, skills or procedures and (2) the appropriate time and place to develop or renew their own performance-based competence.

A literature search and prior investigation revealed that teacher acceptance of performance-based criteria and training materials are important factors in their utilization for inservice education. A master list of teaching competencies was identified in the ten model Elementary Teacher Education Projects funded by the U.S. Office of Education. These recommended terminal behaviors were grouped into ten general areas, and a survey instrument was constructed for each area.

A 50 percent stratified, random sample of Delaware classroom teachers was asked to respond to a questionnaire that included one of the following recommended general areas of teacher competency:

1. Specifying Learning Goals
2. Assessing the Student
3. Diagnosing Student Characteristics
4. Planning Long-Term and Short-Term Learning Programs
5. Guiding Students in Their Learning Activity
6. Guiding Off-Task Student Behavior
7. Employing Teamwork with Colleagues
8. Enhancing Personal and Professional Development
9. Using Instructional Media and Laboratory Equipment
10. Relating to Local Conditions

Each instrument included seven questions regarding about twenty terminal behaviors.

1. Do you perform this activity?
2. Do you feel teachers should be able to perform this activity?
3. How important is this activity for teachers?
4. Where did you learn to perform this activity?
5. Where should teachers learn to perform this activity?
6. When did you learn to perform this activity?
7. When should teachers learn to perform this activity?

The questionnaires were distributed via state courier service. Approximately thirty percent were returned for each general area. There were no significant differences in ranking of objectives by elementary and secondary school teachers. They generally assigned similar ratings of relative importance to teaching. It was concluded that certain objectives were more acceptable than others and could be used for planning pre and inservice training programs for teachers.

DESIGNING A MODEL FOR DEVELOPING LEARNING MATERIALS THAT PROVIDES ELEMENTARY TEACHERS WITH CONTENT BACKGROUND IN SCIENCE IN AN INSERVICE WORKSHOP FORMAT

Winston E. Cleland
University of Delaware
Newark, Delaware

One often hears teachers complain about irrelevant or inferior inservice programs which they are forced to attend each year. This paper discusses a model for designing inservice workshop materials that are relevant for teachers who are attempting to institute one of the new inquiry based elementary science programs (SAPA, SCIS, ESS, etc.) in their classrooms. The model is designed to provide the teachers with content background in an area of physical science while teaching them the process skills needed to successfully utilize new curricular materials with their children.

The model sets up four stages for development of a learning package suitable for inservice programs.

1. The new curricular materials that are being adopted by the teachers in the prospective workshop are reviewed.
2. Relevant content areas are delineated and a small coherent set of science concepts is chosen for inclusion in the workshop learning package.
3. The set of science concepts are behaviorized. They are broken into a manageable set of behavioral objectives that should serve as the vehicle for choosing appropriate workshop activities.
4. Workshop activities are chosen that relate to the set of content objectives and incorporate materials equipment, and if possible, actual exercises from the curriculum to be adopted.

The workshop exercises should be activity centered with as little lecture as possible.

This paper describes how this model is used to develop a learning package in Newtonian Mechanics. The Newtonian Mechanics Module is behaviorized. The activities are laboratory centered with the teachers using equipment and, in some cases, exercises from the SAPA materials. Pretests and posttests can be used to evaluate the participants, the module, or diagnose learning difficulties. Field tests of the module and its evaluation are discussed.

Developing new approaches to the inservice training of science teachers is one part of a comprehensive plan to improve science instruction in the Delaware Public Schools being implemented by the Del Mod System.

EVALUATING THE PREPARATION OF CLASSROOM OBSERVERS BY AUTO-TUTORIAL VIDEO TAPED UNITS

Sally G. Kehoe

and

Carlton W. Knight
University of Delaware
Newark, Delaware

Through this research the authors were able to determine the effectiveness of four auto-tutorial video tape units which were designed to teach preservice and inservice teachers to use simplified objective data gathering classroom analysis techniques. These units were produced as part of a General Science Instructional Strategies Project supported by the National Science Foundation and the duPont Corporation through the Del Mod System. Each unit included a fifteen minute video tape, a printed manual, and accompanying worksheets.

The following hypotheses were tested:

(1) With only one exposure, observers will be able to demonstrate 80 percent competency for each of the specific data gathering techniques in a simulated classroom demonstration.

(2) There will be no difference ($p \leqq .05$) between the ability of the experimental preservice and inservice groups to learn and perform the auto-tutorial units and the control group.

(3) There will be no difference ($p \leqq .05$) between the ability of preservice and inservice teachers to learn and perform the data gathering techniques.

The research design utilized the following groups selected at random from the available population: (1) an experimental sample of ten inservice teachers, (2) an experimental sample of ten preservice teachers, and (3) a control sample of ten individuals, five inservice and five preservice teachers. A post-test only control group design was selected because (1) all participants were assumed to be of equal ability, based upon their universal lack of experience, and (2) to avoid contamination resulting from pre-test exposure to the observational procedures.

During the initial session all members of the experimental groups were exposed to each of the four auto-tutorial video tape units and were given the accompanying manuals. A week later, on the morning of the post-test, the control group was given one hour of exposure to only the introductory section of the four printed manuals.

In the post-test session all participants were required to demonstrate their ability to gather the kinds of data presented in the four auto-tutorial units. These data were compared to a data key constructed for each demonstration-data gathering unit. The criterion key was developed from the data gathered by two trained staff observers and a video tape record of the four performance demonstrations.

Analyses of the post-test data revealed 82.5 percent of the experimental subjects attained the 80 percent competency level required of Hypothesis One. Hypothesis One, therefore, was accepted.

Pooling the two subgroups of five pre- and five inservice teachers into one control group was justified because a univariant analysis of the differences between the dependent variable means revealed nonsignificant F ratios. When comparing the means of the preservice experimental, inservice experimental and pooled control groups, none of the univariate F ratios for the four techniques or the multivariate F was significant. Thus, Hypothesis One and Hypothesis Two (orthogonal comparisons between the two experimental groups) were not rejected.

Orientation to each technique through the background philosophy and performance description presented in the respective manual introductions appeared to be sufficient exposure to enable the participants to demonstrate the required proficiency. The lack of significance may have been caused by (1) over-exposure by the control group to each technique, (2) the lack of practice by the experimental groups between the initial and post-test sessions, and (3) very large within-groups variance. A post-test questionnaire revealed a high degree of interest in and a very positive reaction toward learning classroom observational techniques through the use of auto-tutorial video taped units.

A COMPARISON OF THE RETENTION LEVELS RESULTING FROM THE TRADITIONAL AND MODULAR LABORATORY APPROACHES

Carlton W. Knight
University of Delwware
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and

Gary E. Dunkleberger
Alexis I. duPont High School
Greenville, Delaware

This research was undertaken during the Fall of 1972 to determine whether certain newly designed modularized laboratory units resulted in higher student concept retention levels than resulted from the more traditional laboratory instruction. These seven units were created during the development of a modularized Computer Assisted Testing (CAT) curriculum for a ninth grade Introductory Chemistry-Physics (ICP) course.

One hundred-twenty six students enrolled in the ICP class were randomly divided into two groups. The control group attended (1) large group lectures, (2) small group seminars, and (3-T) the traditional labs while the experimental group attended the same (1) lectures and (2) seminars, but participated in the(3-M) modularized laboratory units. Modularized laboratory instruction enabled students to work at their own speed while completing the various laboratory activities and library research. The modular curriculum was characterized by behavioral objectives, guided self-pacing lab experiments and activities, self-checking quizzes and criterion referenced test items. The control group following the traditional labs experienced a prelab orientation, verbal explanations of expectations that paralleled the objectives provided the experimental group, group laboratory instruction, and a formal laboratory write-up.

Following the completion of the one semester treatment period twenty-four subjects in the control group were paired with twenty-four subjects in the experimental group. These subjects were matched on the basis of their performance on the large group tests and quizzes completed during the seven units. The correlation of the matching criteria for the subjects in the twenty-four pairs was 0.99.

A comparative evaluation instrument was administered simultaneously to all students at the conclusion of the fall semester. This test consisted of twenty-five, four-option multiple choice questions. Each question was keyed to an objective from one of the seven preceding units. A test reliability of 0.71 was computed using the Kuder-Richardson 21 formula.

Analyses of the data revealed that in 92 percent of the matched pairs, students participating in the experimental modular labs scored better on the comparative instrument than did their counterparts in the control group. Both members of the remaining pairs (eight percent) obtained the same score.

Students participating in the traditional lab approach missed 1.7 times as many items as did students utilizing the modular approach. This 5.1 item difference (20.4 percent) between the means of the two groups represented 1.19 standard deviations. Significance at the 0.001 level, as computed by the Scheffé test, required a difference of means greater than 3.64. A Wilcoxon's Matched Pairs Signed-Ranks test also indicated significance beyond the 0.001 confidence level.

The importance of this research is reflected by the increasing number of schools attempting to implement CAT programs. Many school personnel, however, are concerned about the effect of the modularized format commonly associated with CAT science curricula upon student concept retention. The results of this research strongly support use of the CAT adaptable modularized format previously described to increase student concept retention levels in ICP courses.

PAPER SETS

Session C. Implications of Piaget's Theory for Science Teaching

Presiding: Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

1. "An Investigation of Portions of a Model Hierarchy for the Acquisition of the Concept of Speed in Children." Daniel E. Kavanaugh, Guilford Public Schools, Guilford, Connecticut.
2. "Affective and Cognitive Development: Comparison of Need Achievement and Risk Level with Piagetian Levels of Cognitive Development." Kenneth J. Osicki, Cleveland Public Schools, Cleveland, Ohio.
3. "Five Formal Operational Piagetian-Type Tasks Using Two modes of Presentation." Donald J. Brown, Peoria Heights High School, Peoria Heights, Illinois.
4. "Formal Operational Thought and Dogmatism." Dale R. Phillips, Westinghouse Learning Corporation, Iowa City, Iowa.
5. "An Investigation of Proportional Reasoning." James H. Hensley, University of Wisconsin, Platteville, Wisconsin.

AN INVESTIGATION OF PORTIONS OF A MODEL HIERARCHY FOR THE ACQUISITION OF THE CONCEPT OF SPEED IN CHILDREN

Daniel E. Kavanagh
Guilford Public Schools
Guilford, Connecticut

The purpose of this study was to test the validity of a model hierarchy of concepts through which a child must pass in order to understand the concept of speed. The proposed hierarchy tested was patterned after the work of Piaget.

The population samples consisted of one hundred and eight subjects in two suburban towns in south-central Connecticut. Individual interviews were conducted using Piaget-type tasks. The five tasks used in the study--- Task I - speed of circular movement with concentric paths, Task II - circular path of objects fixed to a rigid rod, Task III - conservation of uniform speed, Task IV - speed of movements in succession, Task V - uniformly accelerated motion --- were designed to test the upper three levels (ages 9-13) of the proposed model hierarchy of difficulty.

Scalogram analysis techniques were used to test for the existence of the proposed hierarchy of difficulty among all the tasks. A Kruskal-Wallis one-way Anova was used to test the relationship between the subjects' IQ and ability to complete the tasks successfully. The possibility of significant difference in task achievement as related to sex and grade level of the subjects was also tested.

Findings of the study indicated that the five tasks did form a hierarchy but not in the predicted order. The results also indicated a significant difference between performance and grade level as measured by the task scores. A significant difference between the IQ of the subject and his task achievement was found.

Sixty-seven percent of the sample tested were not able to complete the tasks successfully. The average age of formal operational development in this sample was also found to be greater than proposed by Piaget.

The relationship between the sex of the subject and his score on the tasks was not found to be significant in this sample.

AFFECTIVE AND COGNITIVE DEVELOPMENT: COMPARISON OF NEED ACHIEVEMENT AND RISK LEVEL WITH PIAGETIAN LEVELS OF COGNITIVE DEVELOPMENT

Kenneth J. Osicki
Cleveland Public Schools
Cleveland, Ohio

Fourth and sixth grade students were compared according to socioeconomic status, motivation to achieve, risk level, and cognitive development. These descriptive factors were determined according to, respectively, Hollingshead's Index of Social Position, Aronson's nonverbal Expressive Behavior Measure for Motivation to Achieve, three decision making risk tasks, and four Piaget tasks.

The early development of relatively permanent achievement motivation was supported. It was shown that socioeconomic status has little effect on motivation to achieve once it has been established.

Risk preference was shown to have a relationship to achievement motivation, but not to socioeconomic status, grade level, or cognitive development.

There were no significant differences in cognitive development when the two grades were compared, and it was shown that cognitive development did not vary with either motivation to achieve or with risk level.

FIVE FORMAL OPERATIONAL PIAGETIAN-TYPE TASKS USING TWO MODES OF PRESENTATION

Donald J. Brown
Peoria Heights High School
Peoria Heights, Illinois

Five formal operational tasks were presented to a total of 259 subjects in the sixth, eighth, tenth, and twelfth grades. One hundred twenty of the subjects were tested using individual interviews while the remainder were tested in groups.

Three of the tasks were Colorless Chemical Bodies by Inhelder and Piaget, The Island Puzzle by Karplus and Karplus, and a Concentration Problem. The other two tasks, the Switches Problem and the Lamps Problem, were prepared by the author and are logically similar to Colorless Chemical Bodies and the Island Puzzle respectively.

Colorless Chemical Bodies and the Switches Problem were found to be interchangeable. The Lamps Problem was found to measure a lower level of mental development than the Island Puzzle.

Using either method of presentation a positive correlation was found between task score and grade level.

Finally, it was found that the group presentation did not give the same results as the individual interview technique.

FORMAL OPERATIONAL THOUGHT AND DOGMATISM

Dale R. Phillips
Westinghouse Learning Corporation
Iowa City, Iowa

The purpose of this study was to explore possible relationships between certain schemes of formal operational thought and the extent to which a cognitive system is open or closed (degree of dogmatism).

Rokeach's dogmatism scale was administered to 188 eleventh- and twelfth-grade students. From this group a sample of 30 high and 30 low dogmatics was selected.

Each subject then received an individual interview consisting of four Piaget-type formal operational tasks: floating bodies, conservation of displacement volume, flexibility of rods, and correlations. Tasks were selected on the basis of theoretical correspondences with Rokeach's theory of dogmatism. Percentages of subjects performing at the formal operational level on the four tasks were 17 percent, 43 percent, 42 percent, and 57 percent respectively.

Analyses revealed that the low dogmatics' scores were significantly higher than high dogmatics' scores on the flexibility of rods task. It was hypothesized that low dogmatics logically considered all possible factors and separated variables while high dogmatics perceived some factors as irrelevant and failed to logically separate variables.

AN INVESTIGATION OF PROPORTIONAL REASONING

James H. Hensley
University of Wisconsin
Platteville, Wisconsin

The purpose of this study was to clarify the process by which students arrive at proportional thinking by testing the validity of a hierarchical path for the development of proportional thinking in adolescents. The hierarchy under consideration is that proposed by Inhelder and Piaget.

Fifteen male and fifteen female students from each of the sixth, eighth, tenth, and twelfth grades were used in this study. Proportional thinking was evaluated by presenting each subject with two tasks that required proportional thinking and two tasks that required combinatorial thinking.

Statistical analyses were performed to investigate the scalability of the hierarchy levels of proportional thinking. The relationship between sex of the subjects on performance on the tasks and the relation between grade level and performance on the tasks was examined.

The subjects were interviewed individually and scoring sublevels were used to classify performance on each task. The scoring criteria were based upon the subject's ability to give satisfactory responses and explanations for each task part.

CONTRIBUTED PAPERS IV

Session A. Instructional Procedures

Presiding: Vincent Lunetta, University of Iowa, Iowa City, Iowa.

1. "A Study of the Association Between the Use of Individualized, Self-Pacing Science Curriculum Materials (ISCS) as a Reading Course and Gains in Reading Comprehension and Vocabulary Skills of Seventh grade Students." Robert H. Rivers, Highland Public Schools, Highland, Indiana.

2. "An Analysis of the Effectiveness of the Use of Autoinstructional Materials in the Teaching of PSSC Physics by Qualified Physics Teachers." M. Nasim Siddiqi, Directorate of Education, Delhi, India; Paul H. Westmeyer, University of Texas, San Antonio, Texas and Paul J. Cowan, North Texas State University, Denton, Texas.

3. "A Study of the Use of Computer Simulated Experiments in the Physics Classroom." William R. Hughes, Bexley High School, Columbus, Ohio.

4. "The Relationship of Independent Study, Object Visualization, and Anxiety to Hypothesis Formation by College Freshmen in the Biological Sciences." Dorothy M. Brown, Cabrini College, Radnor, Pennsylvania.

A STUDY OF THE ASSOCIATION BETWEEN THE USE OF INDIVIDUALIZED, SELF-PACING SCIENCE CURRICULUM MATERIALS (ISCS) AS A READING COURSE AND GAINS IN READING COMPREHENSION AND VOCABULARY SKILLS OF SEVENTH GRADE STUDENTS

Robert H. Rivers
Highland Public Schools
Highland, Indiana

Science has been proposed as a subject matter context ideally suited to reading instruction because processes involved in doing science seem to be closely related to higher order reading comprehension skills. A new junior high school science curriculum which emphasizes these manipulative and process-oriented skills is the Intermediate Science Curriculum Study (ISCS). Individualized printed materials are the core of the ISCS program; they are highly explicit and easy to read. This, along with favorable reading test data and other factors associated with the program, suggests that the ISCS materials might profitably be used as a vehicle for teaching reading.

While no ultimate answer to the question of what kind of reading program is "best" is likely to be found, an operational approach which would produce predictable gains with certain kinds of students could result from a study of the problem presented. Making an ISCS-Reading course functional in a school which has no developmental reading program and which is already using the ISCS materials, would be an inexpensive, reasonable, and easily justifiable course of action.

This study, then, was designed to determine to what extent the use of individualized, self-pacing science curriculum materials (ISCS) as a reading course is associated with gains in reading comprehension and vocabulary skills of seventh grade low (below grade), medium (at grade) and high (above grade) reading level students. To assure that gains that were the result of maturation and science or other instruction could be accounted for, the following control and treatment groups were established: Group I, Traditional Science (Control 1), Group II, ISCS Science (Control 2), and Group III, ISCS-Reading (Treatment).

Students assigned to these three groups were given the Metropolitan Achievement Subtest, Advanced Reading Test for grades seven, eight and nine. Form Am was administered as a pretest immediately after the beginning of school in September. Form Bm was administered as a posttest at the end of the first semester, in late February. Raw test scores were converted into standard scores. These were used to produce both a descriptive and statistical analysis. For the statistical analysis, eight hypotheses regarding student scores were established and tested to determine the extent of association between gains observed and the use of the ISCS materials. An analysis of covariance procedure was used to test each of the hypotheses.

Results indicate that students in the ISCS-Science and ISCS-Reading courses who were reading below grade level at the beginning of the year made gains significantly above those of below grade level students in the traditional group, during the study period. The same was true for gains made in vocabulary skills.

A more detailed account of the data and statistical test results and their implications will be discussed in the presentation of the paper.

AN ANALYSIS OF THE EFFECTIVENESS OF THE USE OF AUTOINSTRUCTIONAL MATERIALS IN THE TEACHING OF PSSC PHYSICS BY QUALIFIED PHYSICS TEACHERS

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PSSC physics, which was once accepted as the best physics course by many physics teachers, physicists, and science educators and which was most popular in the first few years of its development, is disappearing from American schools; students apparently feel that this course is too difficult.

Paul Cowan developed a set of autoinstructional materials for PSSC physics at the University of Texas in 1962, and these materials, in the form of an adjunct program, were used later by his students as a study guide in a 1964 research study.

Cowan did not use qualified physics teachers in his experimental classes. Teachers working in the experimental classes had no background in physics and were acting only as adult supervisors. Cowan found that there was no significant difference in the mean level of achievement in PSSC physics between students using the autoinstructional materials and students of comparable mental ability, reading ability, and science background not using such materials but taught by a physics teacher in a conventional way.

The purpose of this study was to compare the effectiveness of the teaching of PSSC physics by a physics teacher using a revision of Cowan's autoinstructional materials with the effectiveness of the teaching of PSSC physics in a conventional teacher-taught classroom situation.

The sample was comprised of eight PSSC classes in six schools in Florida (in St. Petersburg, Ft. Myers, Boca Raton, Wente, Garden and Orlando), four classes in each group - experimental and control. The experimental group consisted of 66 students and the control group consisted of 105 students.

The test performances of the group using the autoinstructional materials and the group not using such materials (both being taught by qualified physics teachers) were analyzed to test the following null hypothesis: There is no difference in the mean level of achievement on PSSC physics standardized tests between students using autoinstructional materials and students not using such materials, when adjustment is made for (1) mental ability, (2) reading ability, (3) science background, (4) verbal reasoning ability, (5) mathematical aptitude, and (6) mathematical achievement. The analysis of covariance technique was used to determine whether or not the stated hypothesis was tenable.

Students in the experimental group demonstrated a statistically higher mean level of achievement in PSSC physics than students in the control group. If achievement is accepted as a criterion for measuring the effectiveness of a program, on the basis of the results reported in this study, the autoinstructional materials used to teach physics to students in high schools were more effective than the conventional method of teaching PSSC physics.

A STUDY OF THE USE OF COMPUTER SIMULATED EXPERIMENTS IN THE PHYSICS CLASSROOM

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The major problem of the study was to assess the effect of Computer Simulated Experiments (CSE) on the attainment of process skills and the acquisition of subject matter content in the high school physics laboratory. Subproblems investigated were (a) to assess the effect of CSE on the number of laboratory trials performed, (b) to determine whether the students working with CSE had a favorable attitude toward CSE, and (c) to determine whether less time was required to perform a Computer Simulated Experiment than an ordinary experiment.

During the period of the study, fifty-one students from two physics classes were involved in four laboratory experiments and simulations. There was a random assignment of students to one of three treatment groups. The same students remained in each group throughout the study.

The students assigned to the Laboratory Group performed experiments, collected data, and analyzed the data in the traditional manner. Those assigned to the Laboratory-Computer Group set up the experiments, performed one trial of each experiment to collect a sample set of data, but used computer simulations to obtain data for analysis. Those in the Computer Group had only instruction sheets that described the experiments and used computer simulations to obtain data for analysis.

The process skills investigated were the ability to (1) investigate relationships between laboratory variables as measured by a Data Manipulation Score, (2) reach conclusions as measured by an Experimental Conclusion Score, and (3) use the processes of science as measured by written Process Tests. The acquisition of content was assessed by a Content Examination. The number of trials performed by students was reported on their laboratory reports or obtained from computer print-outs. The attitude of the students in the computer related groups toward CSE was assessed through a Student Attitude Questionnaire. The students reported the time spent in performing the experiments and/or simulations and analyzing the data.

It was found that (1) a computer related group had the highest mean Dáta Manipulation Score, (2) the Laboratory-Computer Group had the highest mean Experimental Conclusion Score, (3) the Laboratory-Computer and the Laboratory Groups had higher mean Process Test scores than the Computer Group, (4) the Laboratory-Computer Group had the highest mean Content Examination scores, (5) the computer related groups required more time than the Laboratory Group, and (6) the Laboratory-Computer Group tended to view CSE as an extension of their laboratory activities while the Computer Group saw it as separated from their laboratory activities.

THE RELATIONSHIP OF INDEPENDENT STUDY, OBJECT VISUALIZATION, AND ANXIETY TO HYPOTHESIS FORMATION BY COLLEGE FRESHMEN IN THE BIOLOGICAL SCIENCES

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This investigation rested upon the basic hypothesis that hypothesis formation can be learned and that different learning environments, as well as selected learner characteristics, do not equally facilitate this learning. The two learning environments under study were independent laboratory work and regular laboratory instruction. The learner characteristics considered were Object Visualization, as measured by Miller's Survey of Object Visualization, and Anxiety Levels, as measured by the nstitute for Personality and Ability Testing's Anxiety Scale.

The study was conducted in Introductory Biology classes during the course of three semesters at a small liberal arts college in suburban Philadelphia. The 108 subjects were all undergraduate females who had no previous college science instruction. The subjects, randomly assigned to sections, were given a hypothesis formation test at one of the following times: after a six-weeks regular lab program; prior to any college science instruction; after one, two, three, or four units of independent study. The hypothesis formation test was evaluated in terms of: a) the number of hypotheses the student formed, b) the precision of the hypothesis, c) the type of hypothesis, that is, inductive or deductive.

The statistical analysis lends credence to the following:

1. Precision in hypothesis formation is increased as time in independent study is increased. Even though the data show a decrease in precision after the fourth unit of independent study, it is the opinion of this investigator that this was due to a fatigue factor.

2. Students completing four units of independent study will form significantly more hypotheses than those having had no college science instruction.

3. Anxiety level is correlated with a student's ability to visualize objects in the third dimension. Anxiety level does not seem to be correlated with the type of hypothesis formed.

In this study, when one examines the correlation between anxiety level and object visualization, a negative correlation (-.255) was found (significant at the 5 percent level). Of greater interest is the distribution of object visualization scores in each of the three major anxiety groups. Low anxiety students show a fairly even distribution of scores with the greatest number of scores concentrated above the sixty-ninth percentile. High anxiety students, however, scored above the fortieth percentile in only one instance.

4. Precision in hypotheses formation seems to have a direct relationship with the numbers and types of hypotheses formed. As precision in hypotheses formation increases so do the numbers of deductive hypotheses.

CONTRIBUTED PAPERS IV

Session B. Educational Objectives

Presiding: William L. Sharp, University of Iowa, Iowa City, Iowa.

1. "An Empirical Evaluation of the Effectiveness of Educational Objectives Used as Guidelines for the Development of Instructional Units." Thomas C. Arnold and Francis M. Dwyer, State College Area High School, State College, Pennsylvania.
2. "A Chronological History of Selected Objectives for the Teaching of Secondary School Chemistry in the United States During the 1918-1972 Period, as Reflected in Periodical Literature." William R. Ogden, East Texas State University, Commerce, Texas.
3. "The Use of Behavioral Objectives by Basis Vocational Science Students." William J. Martin, Williamsport Area School District, Williamsport, Pennsylvania.
4. "Behavioral Objectives, Science Processes, and Learning From Inquiry-Oriented Instructional Materials." Elaine Anderson, Michael Szabo, and George Toth, The Pennsylvania State University, University Park, Pennsylvania and Hermes T. DeMelo University of Bahia, Brazil.

AN EMPIRICAL EVALUATION OF THE EFFECTIVENESS OF EDUCATIONAL OBJECTIVES USED AS GUIDELINES FOR THE DEVELOPMENT OF INSTRUCTIONAL UNITS

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and

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The purpose of this study was to investigate the potential of using educational objectives to provide the guidelines for developing an instructional unit. Behavioral objectives were identified and criterion tests developed to measure Ss performance of the objectives. An instructional unit was then designed and visualized where necessary to provide the Ss with the necessary cognitive skills required to acquire the objectives.

Specifically, the study attempted to (a) determine the effectiveness of the instructional unit in terms of S achievement on test scores for different entering behavior groups and (b) to investigate the influence of entering behavior on achievement of the predetermined educational objectives.

For this investigation the content area selected for instructional development was the human heart. The educational objectives were developed by the authors and verified by a panel of science educators. The criterion tests required that the Ss be knowledgeable of the essential parts of the heart and demonstrate comprehension of this information by understanding the functions of the heart during the systolic and diastolic phases.

The instructional unit developed to facilitate the completion of this task consisted of approximately 2000 words describing the human heart, its parts, and the internal processes which occur during the systolic and diastolic phases. All Ss participating received their respective instructional units in booklet format. Each booklet consisted of the written script which was printed on 37 paragraph type frames in 5 by 8 inch format.

The population of this study was composed of 207 Ss enrolled in the Instructional Media 435 course at The Pennsylvania State University. Each S received a pretest on the human heart, participated in his respective presentation and then received two individual criterion tests. Scores received on the two criterion tests were combined into a 44-item criterion test. Ss were permitted to take as much time as they needed to complete the instructional unit.

A pretest was administered to all participants in the study in an attempt to determine their prior factual knowledge of the subject matter. The scores achieved on this test were then used to assign the Ss to one of three entering behavior groups. Assignment to these groups was made using a statistical model of confidence limits.

The Ss in each of these entering behavior groups (high, middle, and low) received identical instructional units and participated in identical post instructional achievement tests. An analysis of variance was conducted on the scores achieved by the Ss on each criterion measure. Where significant F-ratios (0.05) were found to exist, differences between pairs of means were analyzed via Tukey's W-Procedure.

Of particular concern was the determination whether behavioral objectives could be used to provide guidelines for the development of instructional units and to investigate the relationship between entering behavior and achievement on the specific learning objectives.

Within the limitations under which this investigation was conducted, the following implications may be derived:

a. The use of behavioral objectives can be used to provide viable guidelines for developing instructional units.

b. An instructional unit designed in accordance with pre-established objectives can significantly improve the cognitive ability of an individual.

c. The process of developing instructional units to facilitate S achievement of specified behavioral objectives was found to be an effective technique for reducing differences among Ss entering the learning activity with different levels of cognitive abilities.

Consequently, science educators can produce effective learning packages utilizing behavioral objectives as the guidelines for unit construction.

A CHRONOLOGICAL HISTORY OF SELECTED OBJECTIVES FOR THE TEACHING OF SECONDARY SCHOOL CHEMISTRY IN THE UNITED STATES DURING THE 1918-1972 PERIOD, AS REFLECTED IN PERIODICAL LITERATURE

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The purpose of the study was to prepare a chronological history of selected objectives for teaching chemistry in the high schools of the United States during the period 1918 - 1972, as reflected in selected professional periodicals.

The period 1918 - 1972 was divided into six subperiods on the basis of selected events that were judged to have had an impact on the course of American educational history. The corresponding volumes of six selected professional periodicals were searched for statements of objectives for the teaching of secondary school chemistry. The statements obtained were categorized as knowledge, process, attitude and interest, or cultural awareness. The resulting categories were further subdivided, on the basis of similarities and differences among the statements included, into 18 distinct objective types (five knowledge, three process, five attitude and interest, and five cultural awareness). Statements of the 18 objective types were classified as to frequency of occurrence, category, authorship, and year of publication within each subperiod and across all subperiods to serve as indicators of preference.

Although yearly fluctuations existed with respect to both the numbers of articles and statements concerned with the objectives of secondary school chemistry that appeared in the literature of the 1918 - 1972 period, the number of distinct objective types remained fairly constant. Sixteen of the 18 types identified were found in the literature of all six subperiods. In addition, no objective appeared in the literature of later subperiods that was not present in that of subperiod 1. The following summaries refer to variations in the frequencies of the nine most frequently cited objective types.

1. Statements of objectives involved with the development of "scientific methods of thinking" were among those most frequently cited during all subperiods.

2. Although not quite cited to the extent of objectives related to "scientific methods of thinking" statements stressing the understanding of the "major facts, principles, concepts, or fundamentals" of chemistry were also among the most frequent during all subperiods.

3. Statements calling for the study of "specific topics in chemistry" were most prevalent in the literature of subperiods 1, 3, and 4. Following the close of subperiod 3 they steadily decreased in frequency.

4. Objectives involving the development of "scientific habits of attitudes" were most abundant during subperiods 1 - 4. From a position as the most often cited objective type during subperiod 2, statements of this concern have steadily decreased in frequency.

5. References to the "career development" aspect of chemistry teaching were most frequent in the literature of subperiods 4 and 5.

6. Concern for instruction in the "processes, skills, and techniques of inquiry," as indicated by the frequency of appropriate objective statements, was highest during subperiods 2, 3, and 4.

7. Objectives concerned with "the applications of chemistry to daily life" were most frequently cited during subperiods 1, 2, and 3.

8. Statements concerned with the "sociological implications" of chemistry were most frequent during the years of subperiod 6.

9. Concern for developing an understanding of "the nature of science and scientists" has steadily increased throughout the 1918 - 1972 years. Statements reflecting this objective were most frequent during subperiod 6.

THE USE OF BEHAVIORAL OBJECTIVES BY BASIC VOCATIONAL SCIENCE STUDENTS

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The purpose of this research was to uncover differences among high, middle and low ability groups of students receiving or not receiving statements of behavioral objectives prior to instruction. Four areas were investigated to determine exactly where the advantage of previous knowledge might lie: (1) Terminal Achievement, (2) Critical Operations, (3) Attitude, and (4) Residual Achievement. The content material consisted of eight instructor-developed modules concerning the achievement competency in scientific measuring involving the metric system.

The population of students consisted of 146 vocational students from a large city school. The population was composed of slow learners as identified by mean percentile scores on the math and science Iowa Tests of Educational Development. Treatment was conducted in the actual classroom setting by the researcher who was the science teacher for these pupils.

The experimental treatment consisted of presenting the students with statements of behavioral objectives along with a modular worksheet prior to each modular activity. The control group received only the modular worksheet.

Terminal achievement was measured by a two-day laboratory practical test using the five item multiple choice format. Test items were procured from the statements of the behavioral objectives presented to the experimental group.

An instructor developed attitude scale was used to determine student satisfaction with the instructional procedures as well as individual performance. The scale consisted of ten multiple choice questions.

Critical operations were measured by the analysis of the modular worksheets collected daily. Each critical operation consisted of a student behavior, the development of which was critical to the successful acquisition of the modular measurement skill.

To measure the residual achievement, the students were administered the terminal achievement test two weeks following the completion of the last module.

The results of these four criterion instruments for each student were used in an analysis of variance to discern differences between treatments and among ability groups. The results were also treated with Pearson Product Moment Correlation.

For the terminal achievement test, the analysis of variance yielded F ratios of 8.53 among groups and 64.66 between treatments. Both were significant at the .05 level.

The results of the analysis of variance for the critical operations index demonstrated F ratios of 3.84 among groups and 174.29 between treatments. Both significantly favored the experimental at the .05 level.

The analysis of variance for the attitude scale produced F ratios of .077 for variance among groups and 21.92 between treatments. The latter value was significant at the .05 level.

Finally, the analysis of variance among groups resulted in an F ratio of 11.56 on the residual achievement test. The F ratio for variance between treatments was 13.02. Both were significant at the .05 level.

Thus, significant differences ($p < .05$) were obtained on all four criterion instruments favoring the experimental group (received the behavioral objectives). Pearson Product Moment Correlation indicated significant ($p < .05$) correlation among all four instruments.

BEHAVIORAL OBJECTIVES, SCIENCE PROCESSES, AND LEARNING FROM INQUIRY-ORIENTED INSTRUCTIONAL MATERIALS

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Research into the effects of behaviorally-stated objectives on learning in various instructional programs has yielded mixed results. Perhaps this state of affairs reflects the notion that the utility of objectives is a function of other teaching variables, such as appropriateness of the learning task or congruence with criterion instruments.

Another powerful variable with potential to increase our understanding of behavioral objectives is the cognitive level of the objectives. Modest support for this notion comes from two research studies (Yelon and Schmidt, 1971; Herron, 1971), and the tendency of most instructional materials to concentrate upon the lowest cognitive levels of objectives. The latter point suggests the lack of a fair test which differentiates among various cognitive levels of objectives.

This experimental research investigated the effect of systematically combined high and low level cognitive objectives upon the acquisition of science learning. An additional independent variate of students' facility with process skills in science was also investigated in this study.

An instructional unit based upon a BSCS Inquiry Slide Set was chosen because it incorporated higher cognitive functioning. Equal numbers of knowledge and higher level objectives were developed for the slides and validated by a group of experienced science teachers. A similar procedure was followed for criterion test items. Behavioral objectives were read by the subjects prior to having an experienced biology teacher present the slides and conduct a discussion according to the suggested guidelines. The treatment time consisted of one 75 minute class period. The criterion test (reliability = .77) was then administered. A similar procedure was used for the control group except they received a placebo instead of the objectives.

CONTRIBUTED PAPERS IV

Session C. Student Characteristics

Presiding: James A. Shymansky, University of Iowa, Iowa City, Iowa.

1. "Sex, Race, Junior High Curricula, and the Acquisition of Process Skills." Donald T. Fritz, Gwynn Park Junior High School, Prince Georges County, Maryland and Michael Szabo, The Pennsylvania State University, University Park, Pennsylvania.

2. "An Investigation of Some Cognitive Style Variables and Their Relationship to Science Achievement." Geno Zambotti and Frank Fazio, Indiana University of Pennsylvania, Indiana, Pennsylvania.

3. "High School Chemistry Student Attitudes: Assessment and Analysis." Henry W. Heikkinen, University of Maryland, College Park, Maryland.

4. "An Investigation of Aptitude-Treatment Interaction Using Two Distinct Modes of College Chemistry Instruction and a Selected Set of Student Aptitudes." Bruce D. Parker, Syracuse University, Syracuse, New York.

Prior to the treatment, the 32 subjects who were enrolled in an elementary science methods course completed the Process of Science Test. Based on these test scores, subjects were randomly assigned to treatment groups in a 2 x 2 design. Two class sections with control and experimental subjects in each were included.

The hypothesis that the experimental and control groups were randomly selected from the same population was rejected. The objectives group scored significantly higher than the control group on the criterion test. The hypothesis that the high and low scorers on the Process of Science Test were randomly selected from the same population was also rejected in favor of the high score group. No significant interaction between treatment and process skill was observed.

This study suggests that under inquiry-oriented learning conditions which employ equivalent numbers of knowledge and higher than knowledge learning, the use of behaviorally-stated learning outcomes facilitates immediate learning. Students who exhibit greater facility with processes of scientific reasoning also tend to learn more, regardless of objectives. Furthermore, the objectives facilitate learning for students with high and low process ability.

It seems likely that serious consideration should be given to the role of objectives in science learning where high and low level cognitive objectives are involved. Further research to investigate the independent and joint contribution of objectives to immediate and delayed learning of science seems to be warranted. Research should also be concerned with the identification of those subgroups of learners for whom behavioral objectives are maximally and minimally effective.

SEX, RACE, JUNIOR HIGH CURRICULA, AND THE ACQUISITION OF PROCESS SKILLS

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This study investigated the effects of two junior high science curricula (ISCS, Level II; IPS) on the acquisition of selected process skills of science. Both curricula encourage student induction of generalizations from data. ISCS-II stresses collection of data with emphasis upon individual analysis; IPS emphasizes group analysis. The structure of IPS is predominantly group-paced, where ISCS-II is individually-paced.

In addition to comparative effects of the curricula, sex and race classifications were studied relative to the criteria of process skill acquisition.

The design used in this ex post facto, intact group study was a post-test only with pre-experimental data from school files. Subjects were eighth grade students at an Eastern Maryland junior high school. All had completed a life science course in the seventh grade. Three of six class sections were randomly assigned to ISCS-II, three to IPS. From an initial sample of 88 ISCS-II and 79 IPS, a subset of 48 were randomly selected to attain equal cells for a 2 x 2 (race x treatment) ANOVA. One hundred and two subjects were used in the sex x treatment ANOVA.

A comparison of groups by treatment, sex, and race on pre-experimental measures showed significant race differences favoring whites over non-whites, on verbal, science, math, and verbal reasoning subscores of the Differential Aptitude Test (DAT).

The criterion test was the Process of Science Test (POST) and reflected acquisition of process skills. Analysis of variance of treatment by sex revealed no significant differences (treatment or sex) or interaction effect. Analysis of variance of treatment by race revealed a significant race difference favoring whites over non-whites.

As a check on the source of racial differences, the treatment by race analyses with POST scores as criterion were run using analysis of covariance. Verbal, science, math, and verbal reasoning subscores of the DAT were used as covariates. No significant main or interaction effects were recorded for any of these analyses.

These findings should be interpreted with caution as some conditions of highly rigorous experimental design could not be satisfied in this study.

First, it appears that ISCS-II and IPS facilitate the acquisition of process skills to the same extent. Few studies have compared ISCS-II and IPS relative to science process skills; thus no directional predictions were made.

Second, no sex differences in process skills were observed. One might predict significantly higher scores for males based on research on science achievement; however, these predictions may be invalid for criteria of process skills. It seems likely that process scores are equally attained by males and females.

Third, and most interesting, pre-experimental differences favoring whites over non-whites were evident on the criterion score (POST) after the year long science course. But when DAT scores were controlled through covariance, race differences on the POST test disappeared. It seems that neither ISCS-II nor IPS successfully accommodates instructionally for these race-related individual differences.

Finally, both ISCS-II and IPS in the eighth grade seem to enhance POST scores, with mean scores of 18 and 17 respectively, as compared with a national norm of 22 for tenth graders.

AN INVESTIGATION OF SOME COGNITIVE STYLE VARIABLES AND THEIR RELATIONSHIP TO SCIENCE ACHIEVEMENT

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and

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The cognitive style construct can be defined as the individual's consistencies in his mode of behavior in searching for meaning. Cognitive style generally refers to two kinds of individual differences. They are: a) a capacity or ability and b) stylistic preferences. This inquiry was designed to survey the cognitive style preferences of college students with reference to 1) specific science content material and 2) the individual's basic motivational patterns or the personal values that he holds and the possible relationship of these variables to science achievement.

Two instruments were used in obtaining data. The instrument Cognitive Preference Survey for Physical Science (CPS) was developed by the authors. The format for this instrument was based upon that found in the literature for cognitive preference tests. The validity of the instrument was established based upon the defined construct of cognitive style and the content validity was based upon the judgement of three college professors of chemistry. The instrument gave three preference scores. They were Memory, a preference for simple content facts; Principle, a preference for a concept or theoretical construct; and Questioning, a preference of a higher order processing, that of challenging, questioning, or adding to the concept. The reliability measures were determined to be 0.772, 0.528, and 0.781 for the above three measures.

The second instrument Survey of Personal Values (SPV, by Leonard V. Gordon) was used to provide measures of stylistic values. The six values measured by the instrument were Practical Mindedness, Achievement, Variety, Decisiveness, Orderliness, and Goal Orientation. The validity and reliability as well as normalized data were provided by the author and Science Research Associates.

The student sample used in this study consisted of the 241 non-science majors enrolled in a physical science course and 16 freshmen chemistry majors enrolled in the general chemistry course. All data were collected at the end of the academic year (May, 1973). The statistical analyses used were analysis of variance, t-tests, correlational analysis, and multiple step-wise regressions.

Based upon the statistical analyses used in this study the following findings were noted:

1) The physical science non-majors were significantly higher on the Memory preference score over the chemistry majors while the chemistry majors were significantly higher on the Questioning score than were the physical science students.

2) The physical science students were significantly higher on the Variety value than were the chemistry majors.

3) The chemistry majors had Memory, Achievement, and Goal Orientation as significant predictor variables for course achievement, while the physical science students had Principle, Achievement, and Orderliness as significant predictor variables for science achievement.

4) The predictor variables for males and females differed. The males loaded Orderliness, Questioning, and Achievement as predictor variables with the females loading Principle, Achievement, and Variety as the significant predictor variables.

The physical science non-science majors were further sub-divided into the following groups; Arts and Science Majors, Criminology Majors, Elementary Majors, Business Majors, and Secondary Teaching Majors, in order to investigate possible style patterns among the various academic majors. Step-wise regression equations showed different loadings among the groups.

The cognitive style variables as described by the CPS and the PVS instruments are valuable measurements of individual differences. Both test instruments are easy to use and each requires only about twenty minutes to administer. The results can be useful to curriculum and course designers when preparing materials for use in matching the materials to the styles of their students. Advisors of college students could use, at least in part, the results of these instruments in helping to assess the styles that are indicative of success in a college science course.

HIGH SCHOOL CHEMISTRY STUDENT ATTITUDES: ASSESSMENT AND ANALYSIS

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The study's two main purposes were to (1) develop a reliable, easily-administered and scored attitude-toward-studying-chemistry scale, suitable for use in high school science classes, and (2) investigate specific student variables which might account for the actual range of student attitudes observed toward the study of chemistry after a year's experience in high school chemistry.

A pilot 40-item Likert scale, based on a randomly-ordered listing of twenty favorable and twenty unfavorable statements that students might make concerning the study of chemistry (i.e., "Chemistry is too boring and dry for me"), was administered to 89 high school students at the close of several summer school classes in chemistry. A final 20-statement Likert scale, called the Student Opinion Survey in Chemistry (SOSC), was composed of the ten favorable and ten unfavorable statements from the trial scale which had the highest item-total correlations, thus striving to increase the internal consistency reliability of the scale. The final SOSC scale had a subsequently-determined reliability (Cronbach's alpha) of 0.94, with an estimated inter-item correlation of 0.50.

The investigation of student attitudes was based on an analysis of high school student responses to equivalent (scrambled) forms of SOSC given in September, January, and April, as well as responses to TOUS (Test on Understanding Science, Form W). Students' expected course grade, plans for schooling beyond high school, probability of taking more chemistry, enjoyment of previous science courses, and reasons for taking chemistry were also assessed.

Analysis of variance and covariance techniques permitted the testing of hypotheses related to possible sex differences among the attitude scores. Stepwise multiple regression checked the ability of selected student variables, either singly or jointly, to reduce the amount of unexplained variance among end-year (April) SOSC attitudes.

Some 1300 high school chemistry students, from a range of urban, suburban, and rural schools, constituted the initial testing pool. Usable cases (N = 577) in the subsequent data analysis were those students who had actually completed all three SOSC attitude tests and the TOUS instrument during the school year. For a subset of the students, IQ scores, grades from previous academic courses, and actual teacher-assigned chemistry grades were obtained and analyzed.

Initial attitudes of girls, as indexed by September SOSC scores, were significantly less favorable toward studying chemistry than were the attitudes of boys. No sex differences were found among either mid-year (January) or end-year (April) SOSC attitudes, when initial SOSC attitudes (or initial attitudes and expected grades) were held constant, however. In TOUS, girls achieved significantly higher scores (mean = 34.28) than boys achieved (mean = 32.23).

Among the variables studied, initial course attitude, enjoyment of previous science courses, expected course grade, and probability of taking more chemistry jointly accounted for most of the end-of-course attitude variance explained in the regression analysis. More than 50 percent of end-year SOSC attitude variance could be explained by the variables identified in this study. For a subgroup where intelligence scores were known, the three variables of initial course attitude, verbal intelligence (Lorge-Thorndike), and expected chemistry grade jointly explained 55 percent of end-year attitude variance.

Although most students continued to express favorable end-year attitudes toward the study of chemistry, modest declines in the degree of favorability were noted for both sexes during the school year. This finding is consistent with previously-reported studies showing year-long declines in favorability of student attitudes across many academic subjects and grade levels.

An easily-administered attitude scale for high school chemistry, the Student Opinion Survey in Chemistry, has been developed for further classroom studies and assessment. Through the application of regression analysis, this study has illustrated the possibility of identifying the relative importance of certain factors in accounting for observed variance among student attitudes. Such efforts suggest that further advances in classroom attitude research are possible, even within the confines of pencil-and-paper techniques.

AN INVESTIGATION OF APTITUDE-TREATMENT INTERACTION USING TWO DISTINCT MODES OF COLLEGE CHEMISTRY INSTRUCTION AND A SELECTED SET OF STUDENT APTITUDES

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Educational researchers and theorists have long hypothesized, either directly or indirectly, the interaction of specific individual learner aptitudes (characteristics) and instructional treatment. It was thought that such an aptitude-treatment interaction (ATI) would result in certain students being more successful in one instructional treatment, while other students with differences in aptitude would be more successful in an alternative instructional treatment. Review of the literature related to aptitude-treatment interaction reveals scant evidence for their existence. However, analysis of the reported research findings does indicate several parameters of experimental design which effect the degree of sensitivity with which ATI's can be isolated. The present study was an attempt to isolate ATI's using two distinct modes of college organic chemistry instruction and a selected set of student characteristics. Those specific parameters identified in the literature as producing the most sensitive ATI experimental design (controlled presentation of treatment stimuli, factorially simple personological variables, and specific criterion variable) were employed in the study.

A lecture format and a Keller Plan (self-paced, reading oriented, tutorial) format were the two instructional methods examined. The student variables measured were college general chemistry grade, reading comprehension, and speed of reading comprehension as measured by the Davis Reading Test (Form 1D), and the four personality factors of responsibility, sociability, ascendancy, and emotional stability as measured by the Gordon Personal Profile. Attitude, measured by a Likert-type questionnaire, and achievement, measured by a comprehensive final semester exam, were used alternatively as criterion variables.

The data were analyzed using a modified version of the homogeniety of slope multiple regression technique. This type of analysis is particularly well suited for use in ATI research in that it allows for the most precise possible analysis of individual variation within treatment group.

Using achievement as the criterion variable, there was no significant main treatment effect observed ($\alpha = .05$). In addition, none of the seven measured student variables was observed to significantly interact with treatment. A disordinal interaction with the reading comprehension variable was significant at the .08

alpha level. Within the lecture format, reading comprehension showed a very slight negative relationship with achievement. Within the Keller Plan format, reading comprehension showed a marked positive relationship with achievement. It must be stressed that this interaction is significant only at $\alpha = .08$.

Using attitude as the criterion variable, a significant main treatment effect was observed ($\alpha = .05$). Students in the Keller format course recorded a significantly more positive attitude. Two of the measured student variables, responsibility and sociability, significantly interacted with treatment. Responsibility showed a marked negative relationship with attitude within the lecture format, and a marked positive relationship with attitude within the Keller Plan format. Sociability showed a very slight positive relationship to achievement within the lecture format and a marked positive relationship to achievement within the Keller format. Both of these aptitude-treatment interactions, the ordinal ATI with sociability and the disordinal ATI with responsibility, were significant at $\alpha = .05$.

The degree to which the total set of measured student characteristics could predict attitude or achievement within each treatment group and the predictive value of each individually measured student characteristic to achievement or attitude within each treatment group was analyzed by stepwise multiple regression analysis.

CONTRIBUTED PAPERS IV

Session D. Teacher Education

Presiding: Vernon Troxel, Miami University, Oxford, Ohio.

1. "Credibility of the Communicator: A Paradigm for Attitude Change for Preservice Elementary Teachers Toward Science." Robert L. Shrigley, The Pennsylvania State University, University Park, Pennsylvania.

2. "The Effects of Integrated Science Process Skill Instruction on the Achievement and Planning Practices of Prospective Elementary Teachers." Harold H. Jaus, Purdue University, West Lafayette, Indiana.

3. "Pupil Growth in Classification Skills as a Consequence Measure of the Effect of Learning Site on Pre-Service Elementary Teachers." Richard J. Rezba, Boston University, Boston. Massachusetts.

4. "An Analysis of the Effects of an Undergraduate Pre-Service Teacher Education Program on Selected Personal Characteristics." Edward L. Pizzini, University of Iowa, Iowa City, Iowa.

CREDIBILITY OF THE COMMUNICATOR: A PARADIGM FOR ATTITUDE CHANGE FOR PRESERVICE ELEMENTARY TEACHERS TOWARD SCIENCE

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Science educators agree that elementary teachers as a group have a less than positive attitude toward the teaching of science. Assuming that the profession can hardly afford this liability, the need for attitude research seems obvious. Therefore, the purpose of this study was to test the validity of the attitude paradigm, the credibility of the communicator, as a model for initiating experimental study of the attitude of preservice teachers toward science and the teaching of science.

One of the theoretical models common to attitude research in social psychology is the credibility of the communicator. Basic to the theory is the premise that expertise and trustworthiness of a communicator affects attitude change of recipients toward the position advocated by the communicator.

A Likert-type response instrument was developed to test the preservice teachers' beliefs concerning the professional credibility of the science methods instructor. The intent of the statements was to test the instructor's past or present, direct or indirect relationship with the teaching of science in the elementary school classroom. The statements encompassed such topics as (1) public school teaching experiences, (2) teaching of science content in methods courses, (3) modeling various modes of science teaching, (4) responsibility to students after course completion and (5) professional research and writing.

The instrument was administered to a sampling of 286 third year preservice teachers at four Midwest colleges and universities. A frequency count and percentage on each of the statements on the instrument were computed for each of the five response categories. In interpreting the findings, criterion was reached and a component considered valid only if 70 percent or more of the respondents were in agreement with a credibility statement.

Preservice teachers rated some teaching behaviors and qualifications as far more credible to the science educator than others. In part, the components of the paradigm that reached criterion were that the instructor of science methods courses:

(1) should have taught elementary science.

(2) draw from a store of practical experiences.

(3) model many modes of teaching.

(4) be competent in science content.

(5) have a close liasion with public school teachers.

Lesser credible components (i.e., those that did not reach criterion) were that the science educator:

(1) teach young children concurrently with college science methods.

(2) counsel former students in their beginning years of teaching.

(3) involve himself in research and professional writing, including the writing of children's science textbooks.

THE EFFECTS OF INTEGRATED SCIENCE PROCESS SKILL INSTRUCTION ON THE ACHIEVEMENT AND PLANNING PRACTICES OF PROSPECTIVE ELEMENTARY TEACHERS

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The primary purpose of this investigation was to determine the effects of integrated science process skill instruction on prospective elementary teachers' (1) achievement of the integrated science process skills, (2) selection of integrated science process skill instructional objectives, (3) writing of integrated science process skill instructional objectives in science lesson plans, (4) writing of integrated science process skill learning activities in lesson plans, and (5) attitudes toward the use of the integrated science process skills in the elementary classroom. A secondary purpose of this study was to determine the relationship of prospective elementary teachers' open- and closed-mindedness to the five variables listed above.

The dependent variables were measured by several instruments. Achievement in the integrated science process skills was measured by an achievement test. Selection of integrated science process skill instructional objectives was measured by the number of these objectives chosen from a questionnaire containing both integrated science process skill objectives and science content-type objectives. Attitudes toward the use of these skills in the elementary classroom were measured by a 30 item Likert-type scale. The number of written integrated science process skill instructional objectives and learning activities was determined by analyzing the prospective elementary teachers' science lesson plans. The Rokeach Dogmatism Scale, Form E, was used to measure open-and closed-mindedness.

Ninety junior-year prospective elementary teachers enrolled in three intact classes of an elementary science methods course were used as subjects in the study. Instructional treatment was randomly assigned to the three classes. One class received instruction in the integrated science process skills via self-instructional pamphlets. A second class received the same instructional pamphlets plus a three-page persuasive rationale advocating the use of the integrated science process skills in the elementary classroom. The third class received placebo instruction. The subjects received five class periods of instructional treatment and were then administered the dependent measures.

One-way analysis of variance with three treatment levels was used to analyze the scores obtained on the dependent measures. If significant F ratios were obtained, the differences in class means were analyzed by the Newman-Keuls test of multiple comparisons.

Pearson product-moment correlations were used to determine the relationship of open-and closed-mindedness to the five dependent measures.

Significant F ratios ($p < .05$) and significant class mean differences ($p < .05$) were obtained on the:

1. scores of the integrated science process achievement test,
2. number of integrated science process skill objectives selected from the selection of objectives questionnaire,
3. number of integrated science process skill objectives written in lesson plans,
4. number of integrated science process skill learning activities written in lesson plans.

Nonsignificant results were obtained on the:

1. scores of the Likert-type attitude measure,
2. scores of the five dependent measures between the class receiving the pamphlets and the class receiving the pamphlets plus the persuasive rationale,
3. relationships between a prospective elementary teacher's open-and closed-mindedness and the five dependent measures.

PUPIL GROWTH IN CLASSIFICATION SKILLS AS A CONSEQUENCE MEASURE OF THE EFFECT OF LEARNING SITE ON PRE-SERVICE ELEMENTARY TEACHERS

Richard J. Rezba
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An evaluation model was generated to determine the effect of learning site on selected teaching training variables. Measurements were made on objectives in four broad domains: affective, cognitive, performance, and consequence. Data were obtained in each of these domains to determine the effect of learning site on:

1. the attitude of the interns to the pre-service elementary teacher preparation block program and to teaching in general,
2. the attainment of cognitive skills in the teaching of science, mathematics, reading-language arts and social studies by the interns,
3. the use of teacher skills in the classroom by the interns,
4. the cognitive growth of pupils when instructed on specific tasks by interns.

The specific purpose of the paper is to report the findings of the consequence component (number 4) of the evaluation model. The consequence objective was to determine if there were significant differences in cognitive growth in classification skills between pupils taught by field-based interns and pupils taught by university-based, field-oriented interns.

Subjects for the study consisted of college juniors preparing to be elementary teachers and elementary school pupils from the classrooms in which the college juniors were assisting. The juniors were enrolled in the ED 300 methods block program at Boston University, spring semester, 1973. Sixty interns were randomly assigned to either experimental group A, which was field-based, or to experimental group B, which was university-based, field-oriented. Two-hundred and two pupils from the elementary classrooms in which the interns were working were selected to be instructed in classification skills by the interns.

The treatment for the college juniors consisted of one full semester of instruction in the content areas of the ED 300 program. The field-based interns (experimental group A) received all instruction in the school sites selected for the study. Instruction in the content areas was interwoven with experience in the classrooms. For the university-based, field-oriented interns (experimental group B) instruction in the same content areas by the same instructors took place at the University on one day with field experience in schools on another day.

During the final week of the semester, both the field-based and the university-based, field-oriented interns spent a full week in the schools. This was for the purpose of evaluating the interns' teaching performance and the pupils' cognitive growth in classification skills. Prior to the final week of the semester, all interns were given a set of objectives in the area of classification skills and a series of tasks to measure the pupils' competence on each of the objectives. They were directed to: a) pretest four or five pupils in the classes in which they were working; b) design instruction to raise the level of competence in classification skills; c) instruct their pupils for one hour and audio-tape the first 15 minutes of that instruction; and d) have their pupils posttested (parallel form of pretest) by one of the investigators or their assistants within a day of the completion of their instruction.

Two hundred and two pupils were pre and posttested. An analysis of covariance design with repeated measures was generated to test differences between groups. Pretest scores were used as a covariate to adjust the dependent variate, i.e. performance scores on the posttest. Pupils instructed by field-based interns (experimental group A) had significantly greater gains in classification skills ($p < .001$) than did pupils instructed by university-based, field-oriented interns (experimental group B).

AN ANALYSIS OF THE EFFECTS OF AN UNDERGRADUATE PRE-SERVICE TEACHER EDUCATION PROGRAM ON SELECTED PERSONAL CHARACTERISTICS

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Iowa City, Iowa

The purpose of this study was (1) to determine initial measures of the self-concept, dogmatism, and science teaching philosophy of prospective science teachers enrolled in the Iowa-UPSTEP I and II programs, (2) to determine changes in self-concept, dogmatism, and science teaching philosophy of prospective science teachers after participating in the Iowa-UPSTEP I and II programs, (3) to determine the effects of an early exploratory experience program on the development of attitudes toward teaching and related educational concepts, and (4) to establish baseline data for longitudinal evaluation of the effects of the five year Iowa-UPSTEP program on selected characteristics of the participants.

Twenty-three Iowa-UPSTEP I participants, 25 Iowa-UPSTEP II participants, and 22 sophomore students originally selected as Iowa-UPSTEP prospects (but who did not participate in the program) were involved in the study. The control group consisting of 22 sophomore students was similar to the Iowa-UPSTEP II participants in science background, science aptitude, ACT Scores, GPA, rank in class, and college classification.

The instruments for this study included the following: (1) Tennessee Self-Concept Scale, (2) Science Teaching Assessment Test, (3) Rokeach Form E Dogmatism Scale, (4) Minnesota Attitude Teacher Inventory, and (5) Semantic Differential for Selected Educational Concepts.

The experimental design for this study consisted of a one group pretest-posttest design for Iowa UPSTEP I and a pretest-posttest control group design for Iowa-UPSTEP II. In addition, a one group pretest-posttest design was utilized to investigate the effects of early classroom experience as a component within the Iowa-UPSTEP II program. The statistics utilized in this study consisted of the "t" for independent and related samples.

Even though there was positive growth for almost every personal characteristic, there was no statistical difference found in self-concept, science teaching philosophy, or dogmatism for participants in the Iowa-UPSTEP I program. The descriptive data indicated that the participants rated the Iowa-UPSTEP I program excellent in all 20 categories when compared to other courses, instructors, and the objectives of the program.

Statistical difference was found for 16 of the 22 variables investigated in this study for participants in the Iowa-UPSTEP II program. The data indicated that the treatment of Iowa-UPSTEP II participants contributed to significant positive growth in various components of self-concept and science teaching philosophy. As a result of the early experience program, the Iowa-UPSTEP II participants showed positive change in the following educational concepts: Individualized Instruction, Being a Science Teacher, Interaction with Pupils, Importance of Science Teaching Materials, and Process-Oriented Approach to Teaching.

In general, the findings of this study suggest that the experimental Iowa-UPSTEP program was effective in contributing to positive growth in self-concept, science teaching philosophy, and attitude toward educational concepts. The early classroom experience program proved to be of significant value in developing several positive educational concepts.

CONTRIBUTED PAPERS IV

Session E. Learning Behaviors

Presiding: Patricia Blosser, The Ohio State University, Columbus, Ohio.

1. "A Study of Student Verbal Behaviors in Inquiry and Noninquiry Settings in Biology." Delivee L. Wright, University of Nebraska, Lincoln, Nebraska.
2. "Studies on Audiotutorial Teaching of General Biology at Syracuse University." Marvin Druger, Syracuse University, Syracuse, New York.
3. "Home Culture Influence on Learning about Natural Phenomena in School: A Case Study in Sierra Leone West Africa." Tom D. Conkright, University of Illinois, Champaign, Illinois.
4. "Tests of Perception of Scientists and Self." Richard T. White and Lindsay D. Mackay, Monah University, Clayton, Victoria, Australia.
5. "Audio-Tutorial Modules in the Preparation of College Biology Teachers." Martha T. Hatcher, Gainesville Junior College, Gainsville, Georgia.

A STUDY OF STUDENT VERBAL BEHAVIORS IN INQUIRY AND NONINQUIRY SETTINGS IN BIOLOGY

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The purpose of this study was to objectively analyze the verbal behaviors used by biology students in inquiry and noninquiry settings.

Videotaped observations were made in inquiry and noninquiry settings in classrooms of biology teachers. Trained coders identified discrete behaviors according to categories of the Revised Inquiry Analysis System. This is an observational instrument which is a modification of the Cognitive Operations Monitored in the Classroom instrument developed by John R. Anderson and Richard M. Bingman. The observers coded three categories of behavior every three seconds or each behavior change, whichever occurred first. Categories included;

(1) Column One: The category of behavior as defined by the ten verbal influence categories of Flanders Interaction Analysis;
(2) Column Two: The category of student verbal influence which has been defined as being analogous to the definition of the corresponding Flanders' teacher influence category; and
(3) Column Three: The category of the inquiry behavior being used (formulation of the problem, formulation of hypotheses, collection of data, analysis and interpretation of data, drawing of tentative conclusions, assessing, etc.).

Inquiry and noninquiry observational data were collected in one randomly selected class of each of the ten BSCS biology teachers participating in this study. They were teachers in the secondary schools in the Lincoln and Omaha, Nebraska, areas and were participants in the Instructional Staff Development Program in Inquiry which was developed by the University of Nebraska Teachers College in cooperation with the Mid-continent Regional Educational Laboratory, Kansas City.

Results were as follows:

1. The percentage of total teacher talk was significantly lower in the inquiry setting while the percentage of total student talk was significantly higher in the inquiry setting.
2. Variety of verbal influence behaviors used by students was greater in the inquiry setting.
3. Student use of verbalized inquiry behaviors was significantly higher in the inquiry setting.

4. The percentage of time spent verbalizing "factual data" by both teachers and students was significantly lower in the inquiry setting.
5. The percentage of time spent verbalizing "data analysis and interpretation" and "procedures" was significantly greater in the inquiry setting.

STUDIES ON AUDIOTUTORIAL TEACHING OF GENERAL BIOLOGY AT SYRACUSE UNIVERSITY

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Audiotutorial methodology has been used as a basic approach to teaching the introductory biology course at Syracuse University since 1968. The course involves some 800 students per semester, and is taught using audio tapes, slides, film loops and laboratory materials in individual carrels. Students use a guide book which contains an overview, behavioral objectives, key words, diagrams, laboratory instructions, self-quizzes and answers. Within limits, students can proceed on a flexible schedule.

A number of research studies have been done relating to this course. Evaluative studies have been done concerning attitudes and achievement; predictors of achievement have been sought; comparisons have been made between two methods of structuring audio tapes, direct and indirect; the relative effectiveness of written scripts has been compared to that of audio tapes. Presently, a study is being done to determine the effectiveness of a completely self-paced audiotutorial course. Achievement, attitudes, background factors and how individual students pace themselves in this course are being studied.

Results of these studies are summarized and problems in audiotutorial teaching identified which merit future study.

HOME CULTURE INFLUENCE ON LEARNING ABOUT NATURAL PHENOMENA IN SCHOOL:

A CASE STUDY IN SIERRA LEONE, WEST AFRICA

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University of Illinois
Champaign, Illinois

Science educators working in the developing countries have for some time now been very sensitive to the physical environment, adapting individual science lessons to the experiences of the learner. Individual teachers have made laudable attempts to adapt global learning strategies to the local cultural environment, but generally without empirical support for their efforts. This research provides empirical evidence for one culture. Using a proactive inhibition paradigm adapted from educational and laboratory psychology, this research investigates the manner in which information concerning natural phenomena learned in the home culture can interfere with and inhibit the learning of information in the school setting.

Using anthropological field methods, data were collected in order to understand the home culture and especially to develop a base from which to ask students meaningful questions about nature. It was found that there are several natural phenomena of major concern to the Kpa-Mende (one sub-group of the largest ethnic group in Sierre Leone, West Africa) for which they offer explanatory information which is considerably different from what is offered by western science. For example, many Kpa-Mende ascribe to a large frog, said to inhabit the swamplands, the power to create the rainbow. Other qualitative differences in the manner in which the Kpa-Mende relate to these phenomena were noted, but the emphasis in this research is on the informational repertoire.

The sample schools in general were found to offer relatively little explicit science instruction concerning these phenomena. Classroom instruction tended to emphasize more abstract scientific concepts. It was left to the student to apply these concepts to his everyday environment and to resolve the differences from what was taught at home.

Students were interviewed concerning their explanations for twelve of the natural phenomena of importance to the Kpa-Mende. Each interview was two hours, open-ended and administered in Mende by two Kpa-Mende college students. Twenty-eight secondary school boys from one school were interviewed during the pilot study and 117 boys and 53 girls from five schools during the main study.

In the pilot study the phenomena were dichotomized between those with elaborated home explanations and those without. Using a three point grading for school answers, the student responses to phenomena without home explanations were found to be statistically more like the schools than those with home explanations. The main study ranked the phenomena according to the percentage of fathers who discussed a single home culture explanation. Student responses were scored as before. A correlation of the adult percentages with student grouped scores was not significant. However, a correlation of adult percentages with the percentage of students expressing the same explanation was significant at the .05 level.

Six student background variables (school attending, year in secondary school, parent's educational level, place of birth, Selective Entrance Examination score and secret society participation) were used in an attempt to account for individual student differences in scores. The resulting multiple correlation coefficient was significant at the .01 level ($R^2 = .16$). However, none of the partial correlations were significant except for the year in school. This single variable in the curvilinear mode accounted for nearly all of the variations explained.

TESTS OF PERCEPTION OF SCIENTISTS AND SELF

Richard T. White

and

Lindsay D. Mackay
Monah University
Clayton, Victoria, Australia

Tests were developed of the congruence between (1) children's and scientists' perceptions of desirable attributes of scientists and (2) children's self-perception and scientists' perception of desirable attributes of scientists.

The tests should be useful in curriculum evaluation in grades 8 - 11. They avoid some disadvantages of Likert-scale tests: they are free from problems of response set and dogmatism of respondents; it is more difficult for respondents to arrange their answers to score well on the test dimension; and a possible confounding variable, social acceptability of statements to respondents, is controlled.

The tests consist of 20 pairs of statements. The statements in each pair are equally socially acceptable, but one is a better description than the other of how scientists behave. The children are required to select one statement of each pair in response to a question. For the two different tests, the questions are:

(1) Which statement better describes how scientists behave in their work?

(2) Which statement better describes you?

Two hundred and thirty statements describing scientific behaviors were derived from published accounts of objectives of science courses. The statements were sorted into nine groups by 68 distinguished scientists, in order of how important the behaviors were in their work. Forty of the statements, spanning the whole range, were selected. Forty further, more general and not necessarily scientific, statements were generated by asking some teachers to write statements describing attributes of people.

The 80 statements were placed by a Q-sort procedure in 9 groups by 70 science graduates who were training to be teachers, on the criterion of how relevant the behaviors were to scientists in their work. The rankings of the original 40 statements by the distinguished scientists and the teachers-in-training correlated 0.81, strongly supporting the validity of the ranking as a representation of the order of importance of the described behaviors to scientists.

The 80 statements were ranked, by Q-sort, by 150 grade ten children on the criterion of how much they would like people to say the statement about them, whether it was true or not. This was to ensure that the statements paired in the test were equally socially acceptable.

Thirty pairs were selected from the 80 statements. The statements in each pair were ranked approximately equal by the children on grounds of social acceptability, but were ranked substantially differently by the scientists on grounds of importance in scientific work. The 30 pairs were presented to grade ten children, prefaced in some cases by question 1 and in others by question 2. The 20 pairs with greatest discriminating power were selected for the final forms of the tests.

AUDIO-TUTORIAL MODULES IN THE PREPARATION OF COLLEGE BIOLOGY TEACHERS

Martha T. Hatcher
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The preparation of college biology teachers has been studied widely. Numerous suggestions have been made for improving this preparation. One such suggestion was the inclusion of opportunities to acquire basic teaching skills and competencies in the Ph.D. program. The instructional materials produced and tested in this study may form a basis for improved preparation for teaching biology at the college level.

A set of six audio-tutorial modules presenting skills and competencies of teaching were prepared and revised after trial use and evaluation by a population of college biology instructors. The modules were presented to one treatment group but not to another group of graduate laboratory assistants (GAs). Each of the GAs was given a cognitive test and a semantic differential measure of attitude toward teaching. Those using the modules were asked to evaluate each one. An Inventory of Student Perception of Instruction was made by students in the laboratory where each GA was assisting.

Data collected on the evaluation of the modules indicated that the GAs found this modular instruction a reasonable and organized approach to presentation of the materials included. The intent was to minimize the input of outside supervision. This method may prove an efficient way of presenting needed information on teaching procedures and allowing for application in the classroom situation. Graduate assistants did learn from the modules, as evidenced by the significantly higher scores of those who received the modules over those who did not.

There were some significant differences between the attitudes of the two groups as indicated on the semantic differential measure. The short period of time covered may have overshadowed more significant overall differences.

Graduate assistants did evidence some differences in their performance as instructors as perceived by undergraduate students. The significant difference was evident particularly in the section dealing with Measurement and Evaluation. Undergraduates have pointed this up as being a point of contention about graduate teaching assistants. A worthwhile contribution could be considered the lessening of the disenchantment of the undergraduate if this facet of instruction alone were improved.

A CLINIC FOR MANUSCRIPT PREPARATION

Presiding: Ronald J. Raven, State University of New York, Buffalo, New York.

Participants: Members are invited to bring manuscripts that have been rejected, manuscripts being revised, manuscripts in preparation, and manuscripts where referees have disagreed. After some preliminary remarks, the session will develop into a series of roundtable discussions where specific problems, questions, and issues can be approached.